Assessing dietary intake in primary school children

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Abstract

The foods we eat in childhood impact on health in adult life. With the increasing incidence of diet related diseases such as non insulin dependent diabetes and cancer it is important that food intakes are monitored. Further in order to assess the effectiveness of health promotion initiatives methods of assessing intake are required which are both accurate and sensitive enough to detect changes in diet. If nutrient intakes are of interest these methods must include a measure or estimate of the amount of food consumed. Weighing foods imposes a large burden on the subject, may not be practical or possible in some sub-sections of populations e.g. children, and often results in underreporting.

The purpose of this work was to develop methods for assessing dietary intake in 4 to 11 year olds; to assess the relative validity of these methods; to utilise the methods to assess the effectiveness of a dietary intervention and to assess the validity of current methods of assessing portion size for use with children.

Two methods of assessing dietary intake were developed and pilot tested with children aged 4 to 11 years old. A food record designed to measure frequency of fruit and vegetable intake and a food diary with interview using food photographs to measure nutrient intake. Following refinement the methods were used to assess the effectiveness of a fruit and vegetable intervention. In a further study the validity of adult food photographs and food models in estimating portion size with children was assessed in an interview where children were shown known weights of foods.

The food record and food diary were successful in detecting changes in intake of fruit and vegetables as a result of the intervention. The food record was found to be difficult to complete and was accurate in measuring fruit and vegetable intakes only at the group level. Accuracy of children's estimates of portion size were poor, children significantly overestimated food portion sizes on average using both the food photographs and the food models. The precision of children's estimates of portion size was also poor with a large range of over- and underestimates of portion size using both the food models and the food photographs.

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Contributions to PhD thesis

Pilot Study

All methods were developed, data collected and entered, and statistical analysis performed by Emma Foster.

Fruit and Vegetable intervention study

All data were collected by diet interviewers trained by and under the supervision of Emma Foster.

The intervention was designed and implemented by a team from the University of Dundee.

All coding, data entry and statistical analysis were performed by Emma Foster.

Advice on the statistical analysis was provided by Professor John Matthews.

Validity of methods for assessing food portion size with children

Application for ethics was prepared by Emma Foster. All methods were designed and all data were collected and entered onto the database by Emma Foster.

The multilevel ANOVA analysis was performed by Simon Webster. All other statistical analysis were performed by Emma Foster.

Reanalysis of the fruit and vegetable study

All analysis was performed by Emma Foster.

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Chapter 1 Introduction

Diet is implicated in the aetiology of the main causes of mortality and morbidity in the UK (Department of Health, 1991b; Department of Health, 1998). The annual cost to the health service of diet-related diseases is in excess of £2100 million and rising (British Heart Foundation 2001; Statistics Office 2001). The UK Government has implemented numerous dietary initiatives in an attempt to reduce these costs and improve the health of the population (HAZnet 2003; Department of Health 2003a; Department of Health 2003b). In order to monitor the dietary intake of the nation and to measure the impact of health promotion messages and dietary initiatives, effective ways of assessing dietary intake are required.

'To fulfil its responsibilities, Government does need to know what people are eating, what it costs and the amounts of nutrients and other constituents in their foods and diets.' (MAFF, 1991)

Nutritional surveillance on a national scale began with the War-time food survey, the first of which was conducted in 1940 by the Ministry of Food (National Food Survey Committee, 1940-1952). It has been conducted annually ever since (MAFF, 1991). Up until April 2001 the survey ran under the banner of the National Food Survey however the latest report to be published (The Statistics Office 2002) is a combination of the National Food Survey and the Family Expenditure survey known as the Expenditure and Food survey. The Expenditure and Food Survey collects information on food purchasing and consumption at the household level and is the longest established continuous survey of its kind. Details are collected, over a 7-day period, of all foods which enter the house, a description of foods consumed at each meal and the family members and others present at that meal. In 1994 the survey was extended to include foods purchased and consumed outside of the home. The National Food Survey, now part of the Expenditure and Food survey, however collects no data on the distribution of food consumption within the household and therefore individual intakes cannot be determined.

Individual intakes of children were investigated in a one-off dietary survey of children aged 10 to 14 years, The Diets of British School Children, conducted by the Department of Health in 1983 (Department of Health, 1989). In recent years the government embarked on a national programme to monitor the dietary intakes of individuals within the UK population. The Department of Health and the Ministry of Agriculture Fisheries and Food conducted the first National Diet and Nutrition Survey in 1986 examining the dietary intakes of British adults aged 16 to 64 years (Gregory *et al,* 1990). The surveys are now conducted by the Food Standards Agency.

> *'The National Diet and Nutrition Survey provides cross-sectional information on the dietary habits and nutritional status of nationally representative population groups.' (Food Standards Agency, 2001)*

The National Diet and Nutrition surveys to date have been conducted on four different population groups: children aged 1 ½ to 4 ½ years (Gregory, 1995), young people aged 4 to 18 years (Gregory and Lowe, 2000), adults aged 19 to 64 years (Gregory *et al.*, 1990) and people aged 65 years or over (Steele, 1998). The surveys are published at two-yearly intervals meaning a report on each age group will be published approximately every 8 years, if they continue at the present rate. The latest report on the diets of British Adults was published in early 2003 (Henderson *et al.* 2002). The National Diet and Nutrition Survey employs a 7-day weighed intake. The subject burden of this method is high since all foods consumed and leftovers must be weighed. While giving a precise record weighed intake may result in reduced accuracy as the subject changes the diet to facilitate weighing or fails to record all foods consumed (Macdiarmid and Blundell, 1997). The high burden of the method also results in subject selection bias with the more educated and motivated members of the population taking part in the study (Berg *et al.*, 1998). The Food Standards Agency is currently reviewing their dietary surveys to determine the most appropriate methods to collect dietary information (Food Standards Agency 2002a).

The dietary information required by the Food Standards Agency for their national surveys programme consists of determining which foods are eaten, the frequency with which those foods are consumed and the size of portion of each food consumed. From this information nutrient intakes can be determined. Weighing and recording all foods eaten is a time consuming and onerous task for the subject. Methods of assessing dietary intake which shift the burden of recording from the respondent to the researcher need to be investigated, in order that accurate nutritional data can be collected from a truly representative sample of the population under investigation. Alternative methods of gaining a measure of portion size have been explored including the use of average portion sizes and aids to estimating the portion size of foods consumed. Removal of the requirement for the respondent to weigh all foods consumed may result in a more accurate account of the types (although not the weights) of foods eaten.

In collecting information on dietary intake we are for the most part reliant on the subject themselves to inform us about what they have been eating. Aside from a few expensive and time-consuming methods such as observation (Davidson *et al.*, 1986) or the use of bio-markers (Bingham and Cummings, 1985; Schoeller and van Santen, 1982), methods of collecting dietary data are intended for subject completion. Biomarkers may be useful for assessing intake of one nutrient e.g. protein but, as yet, there are no biomarkers of the whole diet which could be used as a replacement for dietary assessment.

Food intake can be a sensitive and personal issue. Many people are aware of diet related health promotion messages and may mis-report their actual intake in order to report a diet they perceive to be more healthy, (Hebert *et al.*, 1995) for example omitting snacks. In addition people may consciously or sub-consciously alter what they actually eat to be more healthy during the time they are under examination. The burden of recording dietary intake may also result in an alteration of the normal diet to facilitate recording (Howat *et al.*, 1994). So while records reflect the foods consumed this does not represent usual or habitual intake. If data are collected retrospectively the subject may have an over-optimistic view of their past diet.

We rely on subjects to record information and can only collect information which the subject is willing and able to provide. Where children are the subjects, cognition and memory may have a huge impact on the ability to obtain accurate reports of diet retrospectively. Other issues such as literacy, ability to describe or estimate portion size and knowledge of cooking practices are potential barriers to eliciting reliable information on the foods consumed. We cannot collect information on children's dietary intake which is more accurate than the information retained by the child without resorting to observation or involving all adults responsible for the child's care.

This thesis describes the development and refinement of a method for assessing total dietary intake in primary school children. It begins with the development and pilot testing of two methods designed to assess the impact of a fruit and vegetable intervention on children's total dietary intake and fruit and vegetable intakes. It documents the subsequent use of the methods to evaluate the effectiveness of the intervention. Further, the validity of the portion size assessment aid used as part of the method of assessing total dietary intake is examined and compared with the validity of another commonly employed portion size assessment tool. Finally the impact of the errors associated with portion size assessment on the apparent success of the fruit and vegetable intervention are quantified.

Chapter 2 Literature Review

2.1 Diet and Disease

2.1.1 Coronary heart disease and cancer

Since the end of the Second World War there has been a shift in the focus of nutrition research away from diseases of dietary deficiency to those associated with dietary excess. The developed world now no longer has a problem with food supply but rather the dietary choices its populations make. The two major causes of death in the Western world, cardiovascular disease and cancer, are both multi-factorial diseases in which diet plays a prominent role (Department of Health, 1991; World Cancer Research Fund, 1997). It is estimated that heart disease and stroke account for over 200,000 deaths in Great Britain every year (Department of Health, 1999). The annual cost to the heath service of treating cardiovascular disease in the UK has been estimated to be £1600 million (British Heart Foundation, 2001). This lead the Department of Health to set a target, in July, 1999, to '*reduce the death rate from heart disease, stroke and related conditions by 40% in those under 75 by the year 2010*' (Department of Health, 1999). Cancer is implicated in one quarter of all deaths with current estimates of 300,000 cancer cases and 160,000 cancer deaths in Great Britain every year. The Department of Health also set a target concerning cancer '*to reduce the death rate from cancer in people under 75 years by at least a fifth by 2010, saving up to 100,000 lives*' (Department of Health, 1999). Diet is a major modifiable risk factor for both coronary heart disease and cancer (Department of Health, 1991b; Department of Health, 1998). Health promotion aimed at preventing cancer and heart disease through diet and exercise has the potential to reduce substantially the cost to the health service of treating these diseases.

2.1.2 Obesity

Obesity is a major health concern and the incidence of obesity is rising in both adults and children (Jebb and Lambert 2000; Wabitsch 2000). It is a risk factor for many chronic diseases including heart disease, cancer and diabetes. In the UK an estimated 30,000 of all premature deaths in 1998 were attributed to obesity, in addition to 18 million days of absence from work due to obesity related illness. The cost to the NHS of treating obesity is around £0.5 billion per year. If the incidence of obesity continues to rise at current rates the estimated cost to the economy in 2010 is £3.6 billion (National Audit Office, 2001). The burden of obesity in terms of both the personal health costs and the economic costs necessitate action to halt this obesity epidemic.

Obesity is defined as an increase in the adipose tissue (Power *et al.*, 1997b). It is the result of an imbalance between energy intake and energy expenditure and may be the result of excess energy intake, lowered energy expenditure or a combination of the two (Livingstone, 2001). In the UK adult population the incidence of obesity has tripled over the last three decades. In 2000-2001 one person in five was obese (National Audit Office, 2001). A number of studies have estimated the scale of the increase in obesity in children. In the UK during the decade from 1984 to 1994 obesity was found to have increased from 5-6% in boys and 9-10% in girls to 9-10% in boys and 13-16% in girls (Chinn and Rona, 2001). The increase in weight and weight for height has been greater in older children, and in Scottish children compared with English children, and has been accompanied by an increase in skinfold thickness (Hughes *et al.*, 1997). A survey conducted between 1996 and 1998 by Rudolf *et al.* (2001) found the proportion of 9 year olds classified as overweight had increased from 15% to 20% and that of 11 year olds from 15% to 33% from 1990. Although the estimates of the scale of the increase in obesity differ, the finding that the incidence of obesity is escalating is worryingly consistent. Moreover these values may represent an underestimate of the scale of the problem as skinfold thicknesses (which give a measure of subcutaneous fat) are more closely related to obesity in children than weight or BMI, the measures most commonly used in studies examining trends in obesity (Livingstone, 2001). Livingstone suggests this greater correlation of skinfold thickness with obesity compared with BMI and obesity, may be due to a reduction in physical activity resulting in a decrease in muscle mass partly offsetting the increase in weight by increasing adiposity. This increase in the prevalence of obesity has occurred despite an apparent reduction in energy intake suggesting a reduction in physical activity may be the cause (Tomkins, 2001). Although obesity is viewed as a disease of the Western world recent studies have found obesity and over-weight are on the increase in other regions of the world including China and Brazil (Wang, 2002).

Probably the most significant co-morbidity associated with obesity is non-insulin dependent diabetes which is characterised by insulin resistance with elevated blood glucose levels in the presence of high levels of circulating insulin (James and Pearson., 2000). Type II diabetes is of major concern as it causes, amongst other complications, an acceleration of CHD (James and Pearson., 2000). It has been estimated that the number of people suffering from diabetes worldwide will increase from 135 million in 1995 to 300 million in 2025 (Seidell, 2000).

Type II diabetes has also been termed adult onset diabetes however more recently, as a result of increasing levels of childhood obesity, cases of Type II diabetes have been identified in children as young as 9 years old of ethnic minority origin (Ehtisham *et al.*, 2000) and white adolescents (Drake *et al.*, 2002). Drake *et al.* (2002) suggest that the *'epidemic of childhood obesity in this country'* will result in more and more cases of Type II diabetes in children being seen.

Not only is the balance of energy intake to energy expenditure important but also the composition of the diet. High total fat intake, high saturated fat intake and low fruit and vegetable intake are all implicated in the aetiology of heart disease, and low fruit and vegetable intake and low fibre intake are associated with increased cancer risk (Department of Health, 1998).

2.1.3 Importance of fruit and vegetable intakes

The strongest association between dietary factors and cancer is that between a low consumption of fruit and vegetables and an increased risk of cancer (Havas, *et al.*, 1995; World Cancer Research Fund, 1997). In particular Willett (1990) describes the inverse relationship between fruit and vegetable intake and lung cancer risk as *'one of the best-established associations in the field of nutritional epidemiology'.*

A high intake of fruit and vegetables is of particular importance in a healthy diet as they are rich sources of vitamins, minerals and non-nutrient antioxidants and can reduce the risk of developing heart disease and cancer (Gillman, 1996).

In a UK cohort study, which examined the relationship of fruit and vegetable consumption to cardiovascular disease and cancer in vegetarians and health conscious people, mortality was found to be substantially lower than in the general population. Daily consumption of fresh fruit was associated with a significant reduction in mortality from ischeamic heart disease, cardiovascular disease and all-cause mortality even after adjustments were made for smoking (Key *et al.*, 1996). Fruit consumption has also been shown to have a strong inverse relationship with cancers of the upper digestive and respiratory tract, cancers of the prostate, bladder and kidney and to be associated with a reduced risk of cancer of the liver and pancreas in a case control study in Italy (Negri *et al.*, 1991).

Negri *et al.* (1991) found a consistent pattern for vegetable intake to be protective against all epithelial cancers; this relationship was particularly strong for green vegetables. Block *et al.* (1992) reviewed studies investigating the relationship between cancer and intakes of fruits and vegetables. Of the studies reviewed 82% found fruit and vegetables to be significantly protective against cancer. On average people with low fruit and vegetable intakes had twice the cancer risk of those with high intakes and regions with exceptionally low intakes of fruit and vegetables had the highest incidence of certain cancers. The authors concluded that *'overall, the evidence of an association between fruit and vegetable consumption and cancer prevention is exceptionally strong and consistent'* (Block *et al.*, 1992).

The potential anticarcinogenic agents in fruits and vegetables include: carotenoids, vitamins C and E, folic acid, selenium, fibre and flavonoids (Steinhmetz, 1991). A reduction in the intake of fruits and vegetables would result in the reduction of a whole host of substances which may have beneficial effects. Steinhmetz (1991) state *'Vegetables and fruit contain the anticarcinogenic cocktail to which we are adapted. We abandon it at our peril!'*

In addition to the beneficial effects of fruit and vegetable consumption on the burden of heart disease and cancers, studies suggest that increased consumption of fruit and vegetables may have other beneficial health effects. Cook *et al.* (1997) found that greater consumption of fruit and vegetables had a favourable effect on lung function. This relationship was strongest for the consumption of fresh fruit. Increased fruit and vegetable consumption may also result in other desirable dietary changes for example amongst people deriving more than 35% of their energy intake from fat an increase in fruit and vegetables resulted in a decrease in the proportion of fat in the diet (Anderson *et al.*, 1994). In addition a low intake of fruit and vegetables may be associated with the development of overweight and obesity (Crooks, 2000) which themselves are major risk factors for diseases such as heart disease, some cancers and diabetes (WHO, 1985; Department of Health, 1991b; Department of Health, 1998). Block *et al.* (1992) suggest that *'substantial public health and clinical benefits could be achieved simply by increasing the public's consumption of fruits and vegetables.'*

The evidence for the benefits of fruit and vegetable intake is such that world authorities are consistent in their recommendations for an increase in their consumption. Thus in, 1990 the WHO set 400g (five 80g portions) of fruit and vegetables as a daily minimum target for consumption (WHO, 1990). Current UK recommendations are for children over the age of two years to consume 3 to 4 servings of fruit and vegetables daily and that adults should aim for 5 servings (HEA, 1992; The Scottish Office, 1992).

2.1.4 Current fruit and vegetable intakes

- **Adults**

Actual intakes are falling short of the mark with mean adult daily intakes of around 200g of fruit and vegetables in the UK in 1990 (Gregory *et al*, 1990). Intakes in Scottish adults are particularly low, estimated to be around 181g per day (The Scottish Office, 1993). Recommendations are that intake of fruit and vegetables in the Scottish population should double by the year 2005 (The Scottish Office, 1993). Anderson *et al.* (1994) studied adults in the West of Scotland and found mean fruit intakes to be below one portion per day and mean vegetable intakes to be just 1.43 portions per day. Considering fruits and vegetables together, mean daily intakes were 2.4 portions per day, half of the recommended level. Only 4% of the population studied were achieving the WHO target of at least 400g per day. The Diet and Nutrition Survey of British

Adults collected dietary data in 1987 and found average daily intakes of fruit and vegetables were even lower at 1.9 and 2.1 servings for men and women respectively (Gregory *et al.*, 1990) significantly less than the recommended '5-a-day'. Despite the apparent higher intakes in West Scotland found by Anderson *et al.* (1994) there are geographical trends for fruit and vegetable intakes to be lower in Scotland compared with England and Wales and to be lower in the North of England compared with the South (Department of Health, 1998). Fruit and vegetable intakes are equally low in the USA: Li *et al.* (2000) found in 1996 only 23% of adults were consuming 5-a-day, with average intakes of 3.4 portions of fruit and vegetables per day. Despite these low intakes people may believe their consumption to be sufficient: Cox *et al.* (1998a) found people believed their intakes were high in comparison with what the average person consumes a phenomenon known as 'optimistic bias' (Arens, 1998). More recently studies have suggested subjects may be reasonably good at evaluating the healthiness of their own diets (Ebrahimi-Mameghani *et al.*, 2003; Hearty *et al.*, 2003)

- **Children**

All available data indicate that children also consume inadequate quantities of fruits and vegetables. The Department of Health survey of 'The Diets of British School Children' (Department of Health, 1989) conducted in 1983 reported that children's intakes of fruits and vegetables were particularly poor, with 10 to 11 year old boys averaging 85.6g of vegetables and 90.7g of fruit daily. The corresponding intakes for girls in this age group were 67.4g of vegetables and 97.4g of fruit daily. Scottish primary school children reported lower consumption of all vegetables compared with other areas of Great Britain and this difference in intake was reflected in a difference in intakes of Vitamin C, Beta-carotene and retinol (Department of Health, 1989). These low intakes in childhood were corroborated by Gibson *et al.* (1998) who investigated the diets of 92, 9 to 11 year old children from South London. She found only 5% had a total daily intake of fruit and vegetables in excess of the 400g target. The children in their study were consuming around one 80g serving of fruit and one 80g serving of vegetables each day. They did however report an extremely high intake of fruit juice of two or three 200g servings per day. This would amount to an intake of around 660g of fruit, fruit juice and vegetables combined. It may be that some children were mistakenly reporting having consumed fruit juice in place of another fruit flavoured soft drink. Most recently, in 1997, the Office for National Statistics conducted the 'National Diet and Nutrition Survey: young people aged 4 to 18 years' (Gregory and Lowe, 2000). During the 7 days for which children recorded their food intake 76% of the boys and 72% of the girls had not eaten any citrus fruits and 61% and 56% respectively had had no green leafy vegetables. Boys consumed on average 72g of vegetables and 107g of fruit per day. Girl's intakes were marginally higher at 75g of vegetables and 113g of fruit on average per day, but still well below the 400g target. In a recent cross sectional study which examined the intakes of Scottish children of 11 to 15 years of age in 1990 and again in 1998 the numbers of children consuming fruit on a daily basis had increased from 49.4% of boys and 60.7% of girls in 1990 to 61.9% of boys and 68% of girls in 1998 (Inchley *et al.*, 2001). Intake of fruit and vegetables may have increased but these levels of intake are still low. During this 8 year time span there was also an increase in the frequency of consumption of chips, sausages, burgers, pies, sweets and chocolate in the study group and a decrease in milk consumption.

Recent studies conducted with children living in the USA show a similar picture. Reynolds *et al.* (1998) during baseline assessments for a fruit and vegetable intervention with children aged 8-9 years old, found that around 20% of their subject population were consuming less than one portion of fruit and vegetables daily and that only 16% were having 5 or more portions per day. Field *et al.* (2003) found fewer than 25% of children taking part in their study were meeting the recommendation to eat five a day. Studies have reported daily fruit and vegetable intakes in US children to be between 2.2 and 2.7 servings per day (Beech *et al.*, 1999; Baranowski *et al.*, 2000; Reynolds *et al.*, 2000).

2.1.5 Importance of diet in childhood

The quality of diet in childhood is important and has consequences for both immediate and long-term health. In their 1992 report on nutritional guidelines for school meals, The Caroline Walker Trust commented that, in the short-term, poor diet in childhood impacts on well being, academic performance and growth and development (Caroline Walker Trust, 1992). Whether poor dietary intakes at the sub-clinical level truly impact on academic performance is an issue which is still unresolved. It has been suggested that sub-optimal intakes of vitamins and minerals in childhood may affect intellectual functioning, behaviour and concentration in the absence of overt signs of clinical deficiency. Such effects would have repercussions on the child's performance at school. A number of studies have investigated vitamin and mineral supplementation and its effects on verbal and non- verbal intelligence. Some have seen beneficial effects (Benton and Roberts, 1988) whereas others saw no difference between supplementation and placebo groups (Nelson, 1991).

Longer term, an inadequate diet in childhood may lay the foundations of many adult medical conditions (Mascarenhas *et al.*, 1999). Poor childhood diet has been associated with an increase in coronary heart disease (Berenson *et al.*, 1998c) cancer and stroke, (Williams, 1983-85) and atherogenesis may begin in early life where children display some of the traditional risk factors for cardiovascular disease, including obesity and elevated plasma lipids (Gaziano, 1998). Fatty streaks are present in the arteries from early in childhood and fibrous plaque lesions are present in children as young as 15 years old (Berenson, 1998a).

Osteoporosis is another disease which has its origins in childhood. Early intakes of calcium and weight bearing exercise impact on peak bone mass, the bulk of which is laid down during adolescence (Mascarenhas *et al.*, 1999). An adequate calcium intake during childhood and adolescence may prevent this debilitating disease.

Eating habits formed early in life may be retained into adulthood (Wardle, 1995; Welten *et al.*, 1997) therefore targeting children with healthy eating programmes may have an impact on their eating behaviour before these habits are fully formed. The British Dietetic Association stated

'The primary school years provide the opportunity to develop good dietary habits during a time of relatively closely controlled school feeding and when it is important to sustain healthy growth... The school career is an ideal time to foster the development of a positive attitude to health'

(British Dietetic Association, 1980).

In addition childhood is suggested as a time when modifications of food choice may be more readily accepted (Wardle, 1995) and the earlier healthy lifestyles are established the more likely they may be to persist or track into adulthood (Mascarenhas *et al.*, 1999).

2.1.6 Tracking of dietary habits from childhood into adulthood

Tracking has been described as the consistency of biological variables through time (Boulton *et al.*, 1995). A number of studies have examined whether tracking of food choices, and other health-related behaviours, occurs from childhood through adolescence and into adulthood. In terms of nutrient intakes, Welten *et al.* (1997) found calcium intakes tracked from adolescence (13 years old) into adulthood (27 years old) with individuals maintaining their relative position within the group over this 15 year period despite an increase in the mean calcium intake with age. Tracking was also seen of fruit and vegetable intakes in US children (Resnicow *et al.*, 1998). Children were recruited at 7-8 years old and completed a 7-day food diary during each of the three following years. They found moderate tracking of fruit and vegetable intakes, which was stronger for subjects in the extreme ranges. Lien *et al.* (2001) found intakes of fruit, vegetables, sweets, chocolates and soft drinks all tracked from 14 to 21 years of age. At the population level as the children aged, fruit and vegetable consumption decreased and intakes of soft drinks increased but the relative ranks within the population remained stable. Boulton *et al.* (1995) followed children from birth to 15 years of age and found tracking of relative calcium intakes and to a lesser degree relative energy intakes. However Robson *et al.* (2000) found low tracking of energy and macro-nutrients consumed as snacks from 12 to 15 years of age.

Craigie *et al.* (2003) found strong evidence for tracking of food intakes from childhood into adulthood. They followed up over 200 people at age 32 to 33 years who had participated in a dietary survey at age 11 to 12 years. They examined tracking of the balance of good health food groups and found significant tracking for 3 of the 5 groups. Intakes of fruit and vegetables; bread, cereals and potatoes; and meat, fish and alternatives were all found to track significantly.

Importantly Berenson *et al.* (1989c) found coronary heart disease and hypertension begin in childhood and risk factors track from childhood to adolescence. In an 8 year follow-up study in the USA of subjects aged between 5 and 23 years old, Bao *et al.* (1996) found tracking of insulin levels from childhood into young adulthood, with 40% of subjects who had high insulin levels at initial assessment still having high insulin levels at 8 year follow-up. Elevated plasma insulin levels are a risk factor for glucose intolerance and diabetes. In addition to the tracking of dietary variables Boulton *et al.* (1995) also saw tracking of serum lipid levels from birth to 15 years of age. People with elevated serum lipids are at increased risk from cardiovascular disease.

Perhaps the most consistent finding is for tracking of obesity from childhood into adulthood. There is an increased risk of adult obesity associated with childhood obesity after the third year of life (Overweight and Obesity in Children Taskforce, 2000). Whitaker *et al.* (1997) found that children who were obese after the age of 6 years had a 50% probability of being obese as an adult compared with only a 10% probability for children of normal weight. More recently Craigie *et al.* (2003) found significant tracking of BMI from childhood (11 to 12 years) into adulthood (32 to 33 years), moreover 95% of children in the highest quartile of BMI at age 11 to 12 years were overweight or obese at age 32 to 33 years. The ability to predict adult obesity from childhood BMI has been shown in a number of studies to increase with age and increasing BMI (Power *et al.*, 1997a; Whitaker *et al.*, 1997; Guo and Chumlea, 1999). Fuentes *et al.* (2003) followed children from birth to 15 years of age. Although birth weight was not found to be predictive of later BMI they found significant tracking of BMI during the first 15 years particularly after the age of 7 years. In 1980 Falkner reported around 33% of all obese adults had become obese as children or adolescents and that the majority of obese children went on to become obese adults (Falkner, 1980). In 2000 Zwiauer estimated that 15-20% of obese adults became obese in childhood and a further 10-15% during adolescence. Therefore the evidence indicates that although the majority of adult obesity does not originate in childhood a large proportion of obese children go on to become obese adults.

The dietary and lifestyle changes to produce weight loss in adulthood have proved difficult to maintain (Birch, 1990) therefore preventing the onset of obesity is vital if targets to reduce obesity are to be met. Berenson *et al.* (1989c) state *'Obesity may have a tremendous influence on cardiovascular risk in later life'* and they suggest prevention of coronary heart disease should begin in childhood as many of the risk factors are modifiable.

> *'Understanding diet and nutritional habits of children is critical to the study of heart disease and to approaches for prevention'*
>
> *(Berenson et al., 1989c).*

2.2 Measuring dietary intake

2.2.1 Dietary surveys of children

As diet in childhood is relevant not only to the child's current health but also to their subsequent health in adulthood, monitoring the quality of children's diets is of utmost importance. The first major survey of British children's diets was conducted prior to the Second World War by Widdowson (1947) using a 7-day weighed intake to examine the diets of over 1000 children from middle class backgrounds. In comparison with data collected in 1997, which also used a 7-day weighed intake (Gregory and Lowe, 2000), in the 1930's children's intakes of energy, iron and calcium were substantially higher. Children of 11 years old in the 1930's consumed on average, 2.3MJ more energy per day than children in 1997 (10.1MJ compared with 7.8MJ), 2.9 mg more iron per day (12.8mg compared with 9.9mg) and 90mg more calcium (810mg compared with 720mg). In terms of energy composition the percentage energy derived from total carbohydrate was similar to current dietary intakes (both at around 51% of energy intake) however percentage energy derived from fat was slightly higher

(37% compared with 35.5%) and that derived from protein slightly lower (12% and 13.5%) in the 1930's. Since the work of Widdowson there have been numerous studies to assess children's dietary intakes. The Department of Health survey 'The diets of British School Children' conducted in 1983 found average intakes of fat to be high with 66% of the children consuming more than the recommended level. They also found low intakes of fruit and vegetables and high intakes of confectionery. Median retinol intakes for all children were below the recommended daily amount (RDA), older girls had low intakes of calcium and riboflavin with 57% and 60% respectively having intakes below the RDA. They concluded that a significant proportion of children would fail to meet the RDA for one or more micronutrients (Department of Health, 1989) The most recent British survey of children's diet is the 'National Diet and Nutrition Survey: young people aged 4 to 18 years' which collected 7-day weighed intakes from a nationally representative sample during 1997 (Gregory and Lowe, 2000). The survey found intakes of confectionery and fatty foods were high and intakes of fruits and vegetables were low. In terms of nutrients, the children had high intakes of fat and sugar and low intakes of some micronutrients in particular iron and calcium. A high proportion of British girls may suffer from iron deficiency anaemia. In a study of white girls from low income families in London Nelson (1993) found 11% to be anaemic. More recently Gregory and Lowe (2000) found 9% of 15 to 18 year old girls from a nationally representative sample to be at risk of anaemia (defined as haemoglobin levels below the WHO lower limit for adult females of 12.0g/dl).

In the USA children's dietary intakes seem no more favourable than in the UK (Cavadini *et al.*, 2000). Over the last 30 years there has been a decrease in fruit and vegetable intakes and dairy intakes and an increase in the consumption of soft drinks leading to low intakes of fibre, folate and calcium. The authors comment that the inadequate intakes of fibre and fruit and vegetables are major concerns (Cavadini *et al.*, 2000). Berenson (1998c) found almost 80% of US children were consuming more than the recommended amount of fat, that is more than 30% of energy from fat and more than 10% of energy from saturated fat. Higher than recommended intakes of dietary fat were also seen by, Kimm *et al.* (1990) who found the mean percentage energy from fat to be 35-36%. Percentage energy from carbohydrate was lower than recommended: 50%

compared with 55%. The authors conclude that the average US child's diet is relatively high in fat, saturated fat and cholesterol.

These worrying food and nutrient intakes combined with the importance of diet in childhood for health in adult life demands action to improve the diets of our children. However as Eck *et al.* (1989) comment, although it is generally accepted that health patterns in childhood mark the beginnings of many health problems not manifested until later life, clear conclusions cannot be drawn until further research on the methodology used to assess dietary intake in children has been conducted. The development of methods which can accurately assess children's diets is essential both for the monitoring of children's diets on a national level and to establish the effectiveness of interventions designed to improve the diets of our children.

2.2.2 Dietary interventions

Although annual deaths from diet related disorders are comparable with those related to smoking, anti-smoking initiatives have proved more successful than dietary interventions at promoting change (Foerester *et al.*, 1995). Food consumption is a more complex behaviour than smoking and dietary interventions need to incorporate more complex messages than the simple message of stopping smoking.

A number of interventions to increase fruit and vegetable intake have been conducted in schools as the school provides the perfect place for dissemination of dietary information in addition to providing food for many of the children attending. Roset *et al.* (2000) state *'School children are at the ideal age to benefit from education to promote healthy eating habits'.* Macaux (2001) discusses the importance of taking advantage of young children's eagerness to learn at a time when food habits are still being established. The school canteen is a suitable place to promote healthy eating habits. Schools are in an ideal position to promote and facilitate healthy eating and the school meal may play a role in the establishment of early healthy eating practices, particularly with primary school children (Williams, 1983-85).

A number of fruit and vegetable interventions have been conducted in the USA as part of a national '5-a-day' campaign. This began in 1988 in California and involved the local health services department, the National Cancer Institute, the agricultural business and, by the end of the campaign, 85% of local supermarket and grocery stores. The intervention included media publicity, point of purchase promotion, brochures, recipes and posters. It resulted in significant increases in public awareness of the health benefits of fruit and vegetables. Fruit and vegetable intake increased in both the white and black communities. The success of this campaign resulted in it being rolled out as a national campaign in 1991. Several school interventions took place. Most of these were multi-faceted interventions incorporating curriculum, newsletters, taste testing and recipe preparation, school meal modifications and parental involvement. The interventions were very labour intensive in terms of teacher time with curriculum content to be delivered 3 times per week. Domel *et al.* (1993) found the intervention significantly increased fruit and vegetable knowledge, increased preferences for fruit, and increased fruit and vegetable snack consumption. Fruit consumption increased but overall fruit and vegetable consumption did not increase significantly. Other school based fruit and vegetable intervention studies have reported modest increases in intake ranging from 0.2 to 0.6 portions of fruit and vegetables per day (Nicklas *et al.*, 1998; Reynolds *et al.*, 1999; Baranowski *et al.*, 2000; Reynolds *et al.*, 2000). Reynolds *et al.* (2000) comment that significant intervention effects, one year post intervention, are encouraging and suggest that the 5-a-day program may produce long-term dietary changes.

In order for the effectiveness of such interventions to be evaluated it is important to have methods which will accurately record dietary intake data in the target population. Domel (1997) states *'More accurate assessment of children's diets could increase awareness of the changes needed to help establish healthful eating habits in children that would decrease the risk of chronic diseases in adults.'*

As diet is implicated in the aetiology of the major causes of premature death in the Western world, national surveys which assess the dietary intake of a representative sample of a country's population are important in identifying eating patterns likely to be detrimental to health. This information can then be used in formulating health policy and healthy eating messages. Monitoring of dietary intake should include individuals of all ages within the population. In particular the monitoring of the dietary intakes of children is of utmost importance due to the impact of diet in childhood on later health status. Appropriate dietary assessment methods are essential in assessing the success of health promotion and healthy eating interventions.

2.3 Dietary assessment

Faggiano et al. (1992) describe measuring dietary habits as 'one of the most challenging activities in epidemiology'. Within the field of dietary assessment there are a number of key terms which are commonly used and confused. Their use within this thesis is defined below:

Validation – Validation is the comparison of results from one method against the true value. For example a child's report of foods consumed at school dinner may be compared with those foods actually seen to be consumed.

Relative validation – A relative validation study compares a new method against a more established method. For example nutrient intakes from a 24hr recall may be compared with nutrient intakes from a weighed record of intake.

Accuracy - Accuracy is defined as deviating only slightly or within acceptable limits from a standard (YourDictionary.com, 2003). In terms of a method of estimating food portion size a method can be described as accurate if the mean value from a series of estimates is close to the actual weight of the food.

Precision - Precision is defined as the number of significant digits to which a value has been reliably measured (YourDictionary.com, 2003). A method can be considered precise if the variability of individual estimates around the mean is low.

Underreporting – Underreporting means the subject reports lower food intakes than those actually consumed. This may be due to omissions of whole foods or under-estimation of portion sizes.

Overreporting – Overreporting means the subject reports higher intakes of food than actually consumed.

Undereating – This is where the subject either consciously or sub-consciously reduces the amount of food they consume during the recording period.

Habitual diet – Habitual diet is a person's 'usual diet', their intake over a long period of time.

Actual intake – Actual intake means the foods actually consumed by the subject during the recording period.

Young and Nestle (1995) state *'The accuracy of estimates of energy and nutrient intake depends on the reliability of three distinct data sets: food intake, food composition and portions sizes'.*

There are a number of methods which are used to estimate the dietary intake of individuals, groups or populations. The majority of these methods were developed for use with, and validated for adults. Each have their relative advantages and disadvantages and which method is most appropriate depends on the specific question being asked. Methods of dietary assessment can be either prospective, which measure current diet, or retrospective, which can measure current or past diet.

Prospective methods

- **Duplicate diet analysis**

Prospective methods include duplicate diet analysis, where the subject prepares or purchases two identical portions of each food consumed (Levine and Morgan, 1991). Duplicate diet analysis does not rely on food composition tables (see Section 2.4.5) as the duplicate portion of food is chemically analysed. Although this method can give a very accurate account of what the subject consumed during the recording period it is very costly due to the extra food costs and the costs of analysis for each nutrient under investigation. It is also very demanding on the subject and therefore there is likely to be subject selection bias in that only very motivated subjects will complete the study. In addition the demand on the subject may result in a change to the normal diet. Therefore although actual intake may be well represented it is unlikely to be representative of habitual or long term intake.

- **Weighed inventory**

The weighed inventory is the method used in many national surveys of dietary intakes (Department of Health, 1989; *Gregory et al.*, 1990; Gregory and Lowe, 2000). This method involves the subject weighing and recording all foods and drinks consumed. The subject is usually instructed on the detail required in the diary and the use of the weighing scales at the start of the study period. The subject may be interviewed at the end of the recording period to ensure all foods and drinks consumed were recorded along with brand or food type and cooking methods. As with duplicate diet analysis this may give an accurate account of the subjects intake during the recording period but diet may be altered due to the burden of weighing and recording all foods consumed, therefore it may not give a true picture of habitual dietary intake. In addition the method is costly due to the need for accurate and calibrated food scales and trained interviewers.

- **Estimated weight food diary**

The estimated weight food diary or household measures inventory also involves recording all foods and drinks consumed at the time of eating. Instead of weighing all foods consumed the subject uses household measures to report the amounts of foods eaten, and/ or may estimate the amount of food eaten at the interview using food models, food photographs or food replicas. This lessens the respondent burden and may result in a better representation of habitual diet (Levine and Morgan, 1991) but also reduces the precision of estimates of nutrient intakes compared with the weighed inventory (Nelson, 2000b). Again the subject is usually interviewed at the end of the recording period and therefore the method is costly in that it requires trained interviewers.

Both the estimated weight food diary and the weighed inventory method are suitable only for subjects who are literate (Morgan *et al.*, 1978) and therefore studies using these methods have a bias towards recruiting educated subjects (Rockett and Colditz, 1997).

Retrospective methods

Retrospective methods can be used to measure present diet, recent diet or diet several years previously. The latter may be used for example to gain a picture of diet prior to the onset of disease. These methods do not involve recording food intake at the time of consumption but rely on the subjects' memory and therefore may be unsuitable for children or adults with failing memory. The memory lapses associated with retrospective studies are minimised when the time between actual food intake and the recall is short. Generally foods which contribute the main part of a meal are remembered better than are snacks and condiments (Gibson, 1990).

- **Diet History**

For the diet history method a trained interviewer asks the subject to describe the foods usually consumed with frequency of consumption and amount (Morgan *et al.*, 1978). Questions are asked concerning usual diet by asking the subject to report the foods consumed in a usual day or week. It may then focus on current diet by asking the subject to report the previous day's intake. A check list of foods usually consumed may also be incorporated and the interview may take place with or without estimation of usual portion size (Barasi, 1997; Nelson, 2000b).

The diet history is a relatively expensive method due to the need for a long (1 to 2 hour) interview by a trained interviewer. Subjects may find it difficult to report 'usual' diet especially if their diet is varied.

- **24hr recall**

The 24-hr recall involves an in-depth interview where the previous day's intake is described. The interviewer may assign average weights to the foods or the subject may estimate portion sizes using food models or photographs. The 24hr recall is generally used to measure the previous day's intake only. It is quick to administer but does require a trained interviewer. The method relies on the subject's memory and is therefore prone to omissions. Single observations provide a poor measure of individual intake (Morgan, 1980; Nelson, 2000b). The 24-hr recall has been described as being of value in estimating population intakes, giving mean values which are comparable with more in-depth methods (Beaton *et al.*, 1979). However 24hr recalls and one day records cannot be used to rank individuals by intake or to estimate the proportion of a population who are at nutritional risk (Garn *et al.*, 1978).

- **Food frequency questionnaire**

The food frequency questionnaire (FFQ) is a list of foods and the subject specifies the frequency with which each food was generally consumed over a stated period, usually the past year. It may include an estimate of usual portion size or standard portions may be used. The FFQ may be administered in an interview situation or may be self-completed and has the advantage of being able to be conducted as a postal survey. The FFQ method is inexpensive as an interview is not a necessary part. The respondent burden is low, (Mullen *et al.*, 1984) however it is prone to errors in memory and overreporting of foods believed to be healthy. In addition the number of foods included in the FFQ influences the subjects reported intake. Krebs-Smith *et al.* (1995) found reported fruit and vegetable intakes were associated with the number of fruit and vegetable items included in the FFQ. Bingham *et al.* (1997) found a food frequency questionnaire resulted in estimates of vegetable intake which were on average 120g per day higher than those reported during four 4-day weighed intakes completed throughout the same year. It may also prove too difficult for people whose dietary intake varies greatly from day to day to answer questions concerning usual intake over a long time period (Gibson, 1990). In addition, recollection of past diet is influenced strongly by current intake.

2.3.1 The length of the dietary assessment period

Dietary assessment methods may attempt to quantify and qualify the food intakes of groups or individuals over a period ranging from 24hrs up to one year. The length of time chosen depends on the purpose of the dietary survey and the nutrients of interest. If group mean intakes are required, one day may be sufficient. For individual intakes a week may be sufficient to get habitual intake of energy and macro-nutrients but for micronutrients longer will be needed (Levine and Morgan, 1991). In fact Nelson *et al.* (1989) suggest 7 days may not be sufficient to accurately rank individuals for any nutrient. The larger the day to day variation in individual intakes, in comparison to the between subject variation, the greater the time period over which diet must be recorded if subjects are to be correctly classified (Nelson *et al.*, 1989). That is, the number of days required will be lowest for those nutrients which some individuals consume regularly and others consume not at all. Conversely nutrients which are consumed infrequently but in large amounts by most members of the population will require the longest period of study (Nelson *et al.*, 1989). Case control studies often attempt to quantify past diet, for example diet prior to the onset of a disease. For these studies longer term intake is required and the previous 6 months or one year's intake may be investigated. Margetts and Pietinen (1997) discuss the importance of defining the relevant time frame over which diet should be measured. This must be balanced with the practical constraints on both the subjects and the study. *'7 days is generally regarded as providing the best compromise between optimal precision, investigator workload and subject compliance'* (Black *et al.*, 1991).

2.3.2 Selecting the most appropriate method

The most appropriate method for a particular study will depend on the nutritional information of interest, the characteristics of the population under investigation and the resources available. Buzzard and Sievert (1994) discuss the importance of population specific methods in collecting dietary intake data from different populations or within a population which includes a range of different ages and cognitive abilities. In order for a dietary assessment method to be of use it must produce valid and reliable data. Reliability is the consistency of measurement across multiple assessments (Baranowski *et al.*, 1997). That is the ability of a method to produce consistent results when assessment is repeated in the same individual. Validity has been described as the extent to which an instrument measures what it was designed to measure. The accuracy of estimations of frequency of consumption of foods, food portion sizes, the data collection procedure and the quality of food composition data all impact on the validity of dietary methods (Elmstahl and Gullberg, 1997).

The validity of dietary assessment methods has been examined in a number of studies. The major problem that validation studies have is that true habitual diet may never be known (Block, 1982). Margetts and Pietinen (1997) discuss that the ideal would be a comparison with a method which measures the truth however in reality there is no such method. Methods of measuring diet are often compared against each other without any means of knowing which method, if any, is valid or has the greatest validity (Black, 2000). The weighed inventory has been considered by some a 'gold standard' (Black *et al.*, 1991) and is the method many studies have used to assess the relative validity of other methods. Bingham *et al.* (1994) used 16 days of weighed records to conduct a relative validation of 24hr recalls, food-frequency questionnaires and estimated dietary records. They found food frequency questionnaires to be no better than 24hr recalls in assessing habitual intakes. The 7-day estimated record gave values closest to those obtained from the weighed records. Weighed records were also chosen to assess the relative validity of a computerised diet questionnaire (O'Donnell *et al.*, 1991) and a semi-quantative food frequency questionnaire (Willett *et al.*, 1985). The advent of the doubly labelled water technique (DLW) (Livingstone *et al*, 1992) to measure energy expenditure in free living subjects has shown that the weighed inventory method is less the gold standard than originally considered.

The methods which are generally thought to be most valid are those which require the most subject commitment and are thus most likely to be reactive, that is may result in a biased sample (Rockett and Colditz, 1997) and a change in dietary intake due to the burden of the method (Krantzler *et al.*, 1982). It is important that the reference method chosen to assess the relative validity of a test method is measuring the same aspects of diet as the test method. For example an FFQ (measuring long-term intake) should not be validated against a single 24hr recall but could be validated against a number of 24hr recalls repeated throughout one year.

2.3.3 Assessing the dietary intake of children

In addition to the problems encountered with adults completing dietary assessment studies such as motivational issues, subject recording bias and subject selection bias, further issues of literacy, writing skills, limited food recognition skills, memory constraints and concentration span are of increased concern when children are the subjects.

Measuring food intake in children of primary school age is particularly problematic and there are few tools designed specifically for measuring diet in this age group. Many studies rely on parental accounts of what their children consume. For example Jenner (1989) mailed a dietary questionnaire to the parents of children aged 11-12 years because they were concerned that the children's comprehension, literacy and knowledge of food and cooking methods would not be sufficient for self-completion. However whilst parents may provide accurate accounts of what their children eat at home they are less able to relay what their children consume at school (Livingstone *et al.*, 1992). It is unlikely parents would be able to report on the considerable amount of snack eating which takes place inside and outside of the home. The accuracy with which parents can report a child's diet may depend on a number of factors including working hours and number of children (Emmons and Hayes, 1973). The alternative, collecting dietary information from the many adults responsible for the day to day care of each child is difficult and time-consuming (Livingstone and Robson, 2000). For these reasons the food intake of young children is difficult to measure. In order to acquire the most accurate information possible from young children it is necessary to develop methods of measuring food intake designed specifically for completion by this age group. Lytle *et al.* (1993) state there is a need to develop ways to *'assess eating behaviour in young people without adult help'*. In 1994 the First International Conference on Dietary Assessment identified developing dietary data collection methods which were sensitive to different ages and cognitive abilities as a research priority (Buzzard and Sievert, 1994).

Methods of obtaining dietary information from adults may be inappropriate for use with children. The accurate self-recording of food intake requires a child to have an adequate concept of time and the ability to identify and quantify foods, along with sufficient concentration and memory spans (Livingstone and Robson, 2000). The accuracy of dietary assessment depends on the communication and understanding between the subject and researcher (Buzzard and Sievert, 1994). This extends to the language and terms used in instructing and/or questioning which needs to be adapted to be appropriate to the target group.

2.3.4 Dietary assessment methods for children and people with lower literacy

Methods which utilise technology have been developed for use with children and other groups with low literacy in an attempt to make dietary recording easier. These include videotaping children's meals, a technique which has been reported to provide accurate information concerning what and how children eat (Rockett and Colditz, 1997). Memory may be a limiting factor in the elderly as with children. Brown *et al.* (1990) used a videotape method, with elderly nuns in a residential home. They list the method's benefits as being quick (about 10 seconds to videotape each meal and 2 minutes to quantify each meal), unobtrusive and relatively inexpensive. It requires little subject commitment and is not dependent on the subject's memory. Brown *et al.* (1990) set up the camera at the end of the food counter. Subjects were asked to place their tray in view of the camera and state their full name. Test trays containing known weights of foods were used to test the validity of the method. Reference photographs were then used to assess the amounts of foods on each test tray so that the researchers estimate could be compared with the known weight of food. The videotape method resulted in underestimation of the amount of foods by on average 6%. Some errors occurred due to foods being concealed, inability to see additions such as salt and different foods that look identical such as whole or semi-skimmed milk. The researchers comment that the group in question finished all foods on their plate but that in most populations videotaping of leftovers would be required. This method has the potential to monitor large numbers of children in a school dinner hall but would not account for foods that were swapped or spilt after purchase. Such technologies may greatly reduce both the respondent's and the researcher's work load. However they would not be practicable for assessing total food intake as even in situations such as residential halls where students consume all meals in the canteen, snacks would go unrecorded. Such methods would be less suitable for use in non-institutional environments and would have difficulty in discriminating between certain types of food and determining cooking methods.

Ammerman *et al.* (1994) developed an interactive touch screen computer based programme for subjects with low literacy. It was based on a talk show format and incorporated an FFQ whereby a picture of the food was shown on screen and the subject was asked to touch a number on the screen to indicate their weekly consumption of that food. This method could be used to collect 24hr recall data from children but an FFQ would be likely to be too demanding in terms of memory and the child's concept of time. From focus groups conducted with children aged 8 to 10 years Cullen *et al.* (1998) found children would respond best to a computer based dietary assessment with a game format where different levels could be reached so that the children gained a sense of achievement on completing each level.

A method whereby the subject photographs all foods consumed and the researcher estimates the weight has been compared against a four day weighed intake (Bird and Elwood, 1983). The authors described the results as encouraging with the subjects reporting the method as acceptable. The method requires less subject commitment while the work load on the researcher in coding and interpreting the photograph is similar to that for a weighed intake. The reported validity of this method, which the authors concede requires further investigation, may be increased by the fact that where a weight was missing in the weighed intake an assumed weight was used for both the diary and the photograph method. This was done to prevent any difference being interpreted as errors in the photograph method. However using the same estimated weight for the diary and the photograph would surely increase the apparent validity of the method. This method suffers from the same problems as the videotaping method in that it would prove difficult to discriminate between types of foods and cooking methods. Perhaps this method could be combined with a short interview to clarify these points.

A variation of the 24hr recall method termed the 'Multiple Pass 24hr recall' was developed by the United States Department of Agriculture with a view to reducing the degree of underreporting in dietary surveys. It is comprised of three phases. During the first phase the subject lists the foods consumed during the previous 24hrs. During the second phase the researcher asks questions to gain more details of the foods listed such as type of bread and spread used in a sandwich, additions of salt, sugar etc. The third phase is a review of the information collected, during which the researcher checks no foods have been omitted and asks the subject to quantify portion sizes using food models. The method is quick and inexpensive and the burden on the subject is low (Johnson, 1996). Johnson (1996) examined the validity of this method in assessing energy intakes in children aged 4-7 years by comparison with energy expenditure measured by doubly-labelled water (DLW). They measured energy expenditure over 14 days and conducted 3 multiple pass 24hr recalls during this period. The multiple pass method was found to give a valid estimate of energy intake at the group level but at the individual level the limits of agreement, as determined by Bland Altman plots (Bland and Altman, 1986), were poor. With younger children of 3-4 years old Reilly *et al.* (2002) found energy intakes to be significantly overestimated, using the multiple pass method, even at the group level compared with energy expenditure measured by DLW. By contrast a study by Tran *et al.* (2000), with women between the ages of 19 and 46 years old, found energy intake to be significantly underestimated by the multiple pass method again compared with energy expenditure measured by DLW.

The validity of this method for use with children of 8 to 9 years of age was assessed by Baxter *et al.* (2002). Foods reported during a multiple pass 24hr recall were compared against observations of school breakfast and school lunch. The accuracy of the children's recalls was poor with 51% of the foods eaten being omitted from the recall and 39% of the foods recalled not having been consumed.

Davidson *et al.* (1986) used observation as the main method of data collection with children aged 7 to 10 years old. They found food intakes to be higher than previously published data and comment that the children acquired more of their total intake out of the home than previously thought and were capable of buying foods for themselves. Parents may be unaware of many of the items their child eats away from home, and indeed for the child, acquiring and eating food may be carried out either subconsciously or without parental approval. Such items may therefore be omitted from a self-reported record of food intake.

It is likely that the higher food intakes seen in this study are a consequence of more accurate recording of the children's food intake. In addition to recording the nature of the foods eaten, trained observers may accurately estimate portion sizes and record plate waste. Observation has the potential to overcome the issue of children sharing or swapping foods. Domel *et a.* (1994) found substantial swapping of food items occurred during school lunch. Observers ideally should go unnoticed in order to prevent the subject changing their behaviour in the knowledge that they are being observed (Simmons-Morton and Baranowski, 1991). Observation is practical only on a very small scale. The study by Davidson *et al* was extremely labour intensive, the children were observed during the first year to establish familiarity and no data were collected. It took a further year to collect 3-day observations of 40 children. Observation is therefore a very costly and time consuming method of assessing dietary intake.

2.3.5 Age at which children may report dietary intake

Livingstone and Robson (2000) report that from 8 years onwards there is a rapid increase in children's ability to provide accurate reports of their dietary intake. Frank (1994) was in agreement, however other researchers suggest 10 years old as the youngest age at which children can provide reasonably accurate reports of dietary intake stating that by this age children's cognitive abilities are similar to those of adults (Baranowski and Domel, 1994; Domel, 1997). Emmons and Hayes (1973) found that children of ages 6 to 12 years old were able to report their diets as accurately, if not more accurately, than their mothers. Accuracy increased with age, with 6-year old children recalling 60.5% of the foods they consumed at school lunch compared with 80.6% by 10 year olds. Emmons and Hayes (1973) comment that the 6-year old children usually knew the names of foods and were able to give considerable quantitative information. However the children sometimes confused the previous day's intake with another earlier day's intake and reported foods consumed for school dinner earlier in the week. Haraldsdottir and Hermansen (1995) found children of 7 years also had difficulty distinguishing the previous day from other days and concluded they were too young to respond to a 24hr recall interview without parental assistance. Children only one year older (8 year olds) however were able to be the sole respondent to a 24hr recall providing the previous day was a week day and followed a usual pattern.

Authors quote a variety of ages after which children are capable of accurately reporting dietary information. This is to be expected since the minimum age for self-completion of a dietary assessment method by children will depend on the method itself. A young child able to respond to a 24hr recall for example may struggle with a more demanding method such as the food frequency questionnaire. It is inevitable that the levels of accuracy which can be expected will be lower with children of a younger age. It is necessary to accept the limitations that age and consequent conceptual ability may impose on studies with young children. The consensus indicates that children below the age of 8-10 years therefore may have difficulties with reporting dietary intake, however they may nevertheless provide a more accurate account of their intake than their parents or other adults.

- **Summary of main points from assessing the dietary intake of children**

Issues to be considered when assessing dietary intake of primary school children
Low literacy
Poor writing skills
Limited food recognition skills
Poor memory
Low concentration span
Dietary methods designed for adults may be inappropriate
Few tools designed specifically for this age group
Parents may be unaware of what their child eats away from home
Diet history and FFQ methods may be too challenging for young children
Accuracy of reports of dietary intakes increase with increasing age

2.4 Validation of dietary assessment methods

2.4.1 Validity of dietary assessment methods used with children as the respondents

Baranowski *et al.* (1986) state that a review of the literature *'revealed no reports of valid and reliable methods for children to self-record their dietary intake.'* Since then there have been a few studies that have examined the validity and reliability of various dietary methods for use with children. Some researchers have used tools designed specifically for children but the majority used methods designed for use with adults and adapted these for use with children.

Rasanen (1979) compared two such adult methods, the 24hr recall and the diet history, with children who were 5 to 13 years of age. The child was the respondent for both methods but the mother was present. The diet history required recall of frequency of intake of foods during the previous year, a task which is very difficult even for adult subjects. They concluded that the diet history is not a suitable method for use with children as it resulted in an overestimation of energy and nutrient intakes. The 24hr recalls repeated during different seasons were suggested as the preferred method but neither method was considered suitable for assessing the diets of individual children. In another study the 24hr recall was compared with a 3-day estimated weight food diary and a 5-day FFQ (Crawford *et al.*, 1994). The FFQ resulted in the largest number of omitted foods, while the 3 day food diary produced the fewest errors in terms of foods reported. The food diary relies least on the child's memory as food intake is recorded at the time of eating.

Ambrosini *et al.* (2003) examined the relative validity of recall of past diet by comparing an FFQ designed to measure intake 10 years previous with 4 x 7-day dietary records completed by adults, 10 years previously. They found reported mean intakes of most nutrients were similar using both methods. The limits of agreement for energy intake were found to be from an underestimate of 45% to an overestimate of 78%. The narrowest limits of agreement were found for percentage energy from carbohydrate and percentage energy from fat. They conclude that an FFQ designed to measure remote diet may give validity comparable with that of an FFQ designed to measure recent diet. This is particularly important where diet prior to the onset of disease is of interest.

Baranowski *et al.* (1986) conducted a validation study with 24 US children aged 7 to 11 years. The children recorded frequency of food consumption, over 2 days, on a diet form. This was validated against simultaneous direct observation. The study was very labour intensive as the observer met the child at 7am and observed them continuously for the following 12 hours. The children completed the diet form at the end of each day therefore the method relied heavily on the child's memory. Interestingly parental assistance was not found to increase the accuracy of the reports. It is suggested this may have been due to the large number of eating occasions which took place outside the home. The percentage agreement between the observer and the child across all food categories was 82.9%, a figure they describe as *'acceptably high'*. They commented that the 2 days recording period may have been sufficiently short to maintain enthusiasm for form completion and concluded that children in this age range are capable of accurately reporting frequency of consumption of foods. This study recorded only foods consumed without any measure of amount consumed.

Children who have school dinners provide a unique opportunity to examine the validity of children's dietary reports as children's choices can be observed and food portions and leftovers can be weighed. Domel *et al.* (1994) compared 9-10 year old children's reported intake from school dinners with actual intake as recorded by direct observation. They found a tendency towards underreporting of food intake but concluded that children in this age group were capable of keeping reasonably accurate food records. Only 40% of the children interviewed were completely accurate in reporting all of the foods consumed; no estimate of portion size was made by the children (Domel *et al.*, 1997). The authors concluded that the level of accuracy seen in this study probably represents the upper level of accuracy of children's reports, since all of the children were served the same meal on a particular day, had a copy of the lunch menu to remind them what they had eaten and completed their records soon after lunch so minimising any errors due to memory (Domel *et al.*, 1994). Including children who take a packed lunch to school would enable the extent to which this memory aid improved children's accuracy in reporting to be assessed. More recently Warren *et al.* (2002) compared children's reports of foods consumed for school dinner and packed lunch with observer records. The children were asked to recall the foods they had consumed within two hours of their meal. Accuracy of the children's recall was increased to 80% with prompting. Children consuming a packed lunch were more accurate in their recalls than children eating a school meal.

2.4.2 The use of bio-markers in assessing the validity of dietary assessment methods

Recently biochemical markers have been used in place of weighed intakes to assess the validity of dietary reports. Urinary nitrogen excretion and doubly-labelled water (DLW) methods have been used to validate reported intakes of nitrogen and energy respectively (Bingham and Cummings, 1985; Schoeller and van Santen, 1982). For validation of dietary protein intakes the amount of nitrogen excreted in the urine is compared with the amount reported to be consumed as protein. Bingham and Cummings (1985) found urinary nitrogen excretion should be approximately 81% of that ingested. Values higher than this are indicative of underreporting and values lower of overreporting protein intakes. Urine should be collected for at least a 24hr period and the completeness of the collection checked. Completeness of a 24hr urine sample is checked by the recovery rate of a metabolic marker known as PABA (para-amino benzoic acid) which subjects are asked to take as a tablet (80mg) three times throughout the collection period.

The DLW method assumes that subjects are in energy balance and therefore energy intake should be equivalent to total energy expenditure (TEE) (Livingstone *et al.*, 1992). Subjects should be weighed at the start and end of validation studies to check they are not in positive or negative energy balance, that is gaining or losing weight. It is a non-invasive method which requires little subject commitment and allows subjects to carry on with their usual daily routine. Water labelled with the heavy (stable) isotope of oxygen (^{18}O) and the heavy isotope of hydrogen (^{2}H) is given to subjects as an oral dose. Loss of ^{2}H from the body occurs only in water whereas the loss of ^{18}O occurs both as water and as carbon dioxide (CO_2). The difference in the turnover rates of ^{2}H and ^{18}O

can be used to calculate the production of CO_2. The rate of CO_2 production can be used to estimate energy expenditure as carbon dioxide is produced in proportion to the heat generated when food is oxidised (McNeill *et al.*, 2000).

Other biomarkers can be used to assess the validity of subjects' reports of their intake of nutrients other than energy and protein. These include serum vitamin C, carotenoids and ferritin, urinary sodium, potassium and creatinine excretion (Gregory and Lowe, 2000; Nelson, 2000b). These may be useful where reported intake of foods which do not contribute greatly to energy intake need to be verified such as fruit and vegetables.

The advantage of using such bio-markers to assess the validity of dietary assessment tools is that they provide an independent validatory measure. If a reference method which relies on self-reporting of diet by the subject is used there is likely to be some correlation between the errors of the reference method and those of the test method (Kipnis *et al.*, 2001). That is for example people may underestimate their consumption of foods perceived to be unhealthy using both the reference and the test method. Bio-markers are however often too expensive, for example DLW, or the methods too cumbersome, for example urinary nitrogen excretion, to be used routinely (Livingstone *et al.*, 1990).

Use of these biomarkers, particularly DLW, has resulted in the discovery that underestimation of food intakes is a common problem in dietary surveys (Livingstone *et al.*, 1990; Black, 2000). This has led to the derivation of energy intake cut-offs, based on multiples of basal metabolic rate (BMR), which can be used to exclude subjects believed to be underreporters (Goldberg, 1991). BMR accounts for the majority of a person's energy requirement and is defined as *'the energy expenditure of an individual lying at physical and mental rest in a thermo-neutral environment, at least 12 hours after the previous meal'* (McNeill *et al.*, 2000). BMR is affected by a person's weight, and body composition, gender and age (Barasi, 1997). BMR can either be measured by calorimetry or estimated from a person's age, gender and weight using equations derived by Schofield (1985). Energy requirements depend not only on BMR but also on the amount of physical activity a person does. In order for the identification of underreporters to be accurate, therefore, an estimate or measure of physical activity level is required. The use of a single cut-off assuming a low activity level fails to identify underreporters with high energy requirements (Black, 2000). Macdiarmid and Blundell (1997) suggest underreporting may be as prevalent amongst subjects with medium or high Energy Intake (EI):BMR ratios as those with low EI:BMR ratios due to differences in physical activity levels. The physical activity level (PAL) is expressed as a multiple of BMR, this is then compared with the ratio of estimated energy intake to BMR (EI:BMR) to determine whether energy intake is likely to be a true reflection of actual intake. A cut-off of 1.55 x BMR is frequently used as this represents a *'probable minimum energy requirement for a normally active but sedentary population'* (Black, 2000). However Black (2000) recommends EI:BMR cut offs be used at the group level using a PAL appropriate to the study population. In addition age and sex specific cut offs have been derived for use with children (Torun *et al.* 1996)

2.4.3 Underestimation of food intakes by adults

Livingstone *et al.* (1998) used DLW to measure total energy expenditure (TEE) over 15 days and compared this with 7 consecutive days of weighed inventory. Overall they found a bias towards underreporting of food intake with mean reported energy intakes being 81% and 82% of TEE for males and females respectively. They suggest this underestimation of energy intake may be due to underreporting, a reduction of energy intake during the recording period or a combination of the two. Black (1996) found 16% of adult subjects underreported energy intake and 15% overreported compared with DLW estimates of TEE. Black (1996) saw no significant bias towards under or overreporting in men but found a bias towards underreporting in women. In a review of studies of energy intake where energy expenditure had been measured using DLW, Livingstone and Black (2003) found a greater tendency for women to underreport energy intake using dietary records compared with men. In the studies reviewed 28% of men and 38% of women underreported their energy intake and 5% of men and 4% of women overreported their energy intake. Valid reports were provided by 67% of men and 59% of women.

Obese individuals have been identified as a group who have a tendency to underreport energy intakes (Bandini *et al.*, 1990). Goris *et al.* (2000) found only one out of 30 obese subjects reported energy intake to within 10% of their energy expenditure measured by DLW. The degree of underreporting increases as BMI increases but underreporting does occur in subjects from all weight categories (Livingstone and Black, 2003). Seidell (1995) states that underreporting of energy intakes and fat intakes increases with increasing BMI. This may be the reason many studies have failed to show a difference in energy intake between obese and non-obese individuals and may explain the fact that obesity is on the increase whereas energy intakes are apparently falling.

Identifying obese individuals as a group who tend to underreport various aspects of their food intake is an important finding which throws question on the appropriateness of excluding underreporters. It may be that by applying these exclusion criteria to our data we are excluding one of the very populations whose dietary intakes we need to understand.

Validation studies, due to their intensive nature often have a small number of study subjects. Differences in the populations studied and the population to which validation methods are applied have resulted in a range of estimates of the extent to which subjects' underreport. An overall tendency for subjects to underreport is a fairly consistent finding.

The extent to which subjects underreport varies depending on the dietary assessment method used. Black *et al.* (1991) reviewed published studies and found that 64% of diet records (both weighed and estimated weight), 88% of diet recalls and 25% of diet histories were below acceptable EI:BMR cut offs. The proportion of subjects underestimating is likely to be even greater than this as they assumed a physical activity level (PAL) of 1.5 times BMR whilst from DLW studies they found mean PAL to be 1.62 for women and 1.78 for men. Men were found to underreport to a lesser degree, reporting higher mean energy intakes, than the women. This seemed to be due to higher mean energy expenditure in the men, meaning the cut off used was too low for this group, rather than greater validity of their dietary reports. Underreporting may occur consciously or sub-consciously and therefore is difficult to combat. This is evident from the fact that in one study even dieticians were found to underreport! (Black *et al.*, 1991). The authors conclude that *'dietary assessment methods have a strong bias towards underestimation of habitual energy intake.'*

2.4.4 Underestimation of food intakes by children

Underestimation of food intakes is also seen when children report their dietary intake (Livingstone and Black, 2003). Unlike with adults societal pressures could push children towards overreporting with children feeling under pressure to finish all foods served and parents wishing to appear to be providing an adequate diet for their child. In comparison with adults, children consume more snacks (Serra-Majem, 2001) and this may lead to increased levels of underreporting as snacks are often forgotten (Gibson, 1990).

The extent to which the problem of dietary underreporting occurs when children are the subjects has been examined in a number of studies. Livingstone *et al.* (1992) conducted a validation of energy intakes of children aged 7 to 18 years from 7 day weighed dietary records using doubly-labelled-water (DLW). Older children reported their own food intake with help from their parents whereas for children of 9 years or younger, parents completed the records on their behalf. They found good agreement between reported energy intake and measured energy expenditure for the 7-year-old children but agreement decreased with increasing age. For the 9-year-old children a slight bias towards underestimation of energy intake was seen and this was even more pronounced in the older children. It is likely that as age increases the child obtains a greater amount of food outside of the home and that parents may not be aware of these eating occasions. Across all age groups (7-18 years) they found poor agreement between reported energy intake and energy expenditure on an individual basis. Livingstone and Black (2003) reviewed studies where children's reported energy intake had been compared with energy expenditure measured by DLW. Again they found a trend for underreporting to increase with age. Children up to the age of 12 years old were found to give reasonably accurate reports of energy intake however in older children the level of accuracy was poor. Underreporting was found to be more prevalent amongst girls and children with a higher BMI.

Underreporting of energy intakes by children has been found to increase with age. (Champagne *et al.*, 1998) This may be due to a shift in the pressure on a child as they age. Young children may feel pressure to eat up their meal whereas adolescents, especially girls may have aspirations towards thinness. The authors comment that they were unable to determine whether underreporting of energy was a consequence of leaving whole foods out or of reporting all consumed foods but underestimating the size of the portions consumed. Bandini *et al.* (1997) used DLW to assess the validity of reported energy intakes of preadolescent girls from a 7-day diary using household measures to estimate portion size. The mean reported energy intake was 88.3% of TEE and again there was a trend for underreporting to increase with age and energy intake. Bandini *et al.* (1997) suggest the increase in underreporting with age may be due to a number of factors including the increased amount of time older children spend away from home where foods consumed may be forgotten. In addition they comment that adolescents may not wish their parents to know what they have been eating and some may have a pre-occupation with weight. On the other hand young children may well receive substantial amounts of help in completing food records. Whether this extra help results in an improvement in the accuracy of the record depends on the parent's knowledge and the amount of food the child consumes away from their parents.

Whereas less complicated methods of dietary assessment may be accurately completed by children as young as 8 years old, Persson and Carlgren (1984) found children of 13 years of age were just reaching the point where they were capable of responding to a diet history interview for themselves (Persson and Carlgren, 1984). Energy intakes from a diet history have been compared with energy expenditure measured by DLW in children aged 3 to 18 years. The diet history showed good agreement at the group level but poor agreement at the individual level. There was a trend towards slight overestimation of energy intake in the younger children using this method (Livingstone *et al.*, 1992).

In a paper reviewing assessment of dietary intake in children, Livingstone and Robson (2000) discuss the trend for increasing underreporting of energy intake with increasing age and comment that this may be because parents assist younger children with recording their food intake whereas adolescents report food intake for themselves. In addition there may be a fall in levels of interest with increasing age along with unstructured eating patterns, which may lead to loss of motivation, forgetfulness and inaccuracies.

The validity of the 24hr-recall as a method for measuring diet in young children was assessed by Lytle *et al.* (1993). Children completed a 24hr recall assisted by a food record. The children's reported consumption of foods eaten was compared with an observer's record of the foods actually consumed. A researcher observed the children eating at school and parents were recruited to make observations at home. They found significant differences between observed and recalled energy intake but no significant difference in nutrient densities. There was 77.9% agreement across all meals and snacks. They conclude that the 24hr-recall assisted by a food record may be a useful tool in evaluating the effectiveness of nutrition education programmes without the need for parental assistance. This makes collecting dietary data much easier and much more cost effective as interviews can be conducted at school and the need to visit or telephone parents is eliminated. Eck *et al.* (1989) found that interviewing the child and both parents in a recall interview concerning the child's food intake gave greater accuracy than interviewing either the father or the mother alone. As previously discussed parents are often unable to report foods their child eats outside the home. The authors did not however interview the child separately; it would have been interesting to examine whether the child also reported with greater accuracy than either parent when interviewed alone. In a further study of the 24hr recall method, three 24hr recalls were collected from children aged 4 to 7 years and validated against TEE measured by the DLW method (Johnson, 1996). Whilst Johnson (1996) found that at the group level estimates of energy intake were comparable to estimates of energy expenditure, at the individual level the agreement was poor. However this would also be the case with adults as on any one day an individual may be in positive or negative energy balance. The study would need to measure energy intake and expenditure over a longer period to assess the validity of the method for measuring individual intakes.

2.4.5 Sources of error in dietary assessment

Although there is an extensive body of research into methods of assessing dietary intake there is still a lack of methods which are both accurate and practical for use with free living populations (Mullen *et al.*, 1984). Mertz (1992) describes both the knowledge of and methodology for determining nutrient intakes as inadequate. There will always be errors associated with the measurement of a population's habitual diet (Berg *et al.*, 1998.) as *'what people eat is not what people say they eat'* (Arens, 1998). In order to improve methods of dietary assessment it is important to understand why this is the case. An understanding of why people underreport their food intake is essential to fully comprehend the problem of dietary underreporting (Macdiarmid and Blundell, 1997).

Mertz (1992) posed the question *'which foods are left out when intake is underreported... Do we underreport across the board or do we fail to report those items that have bad connotations?'*. They discuss that the impact on nutritional intake data would be very different with underreporting across the board resulting in all nutrients being underreported to the same degree whereas underreporting of 'unhealthy' foods would alter the nutrient composition of the diet. Following a review of studies where reported energy intake was validated against energy expenditure measured by doubly labelled water Livingstone and Black (2003) concluded that *'underreporting is a selective rather than a general phenomenon'*. Protein intake was found to be underreported by 2% on average whereas energy intake was underreported by 14%. Those subjects reporting low energy intakes were found to report higher percentage energy from protein and starch and lower percentage energy from fats and sugars.

These findings confirmed those of Black *et al.* (1997) who found individuals identified as likely to have underreported their intake reported significantly lower intakes of fat and sugars compared with the rest of the study group. Schoeller (1990) discussed the fact that selective omission of snack foods would result in reported intakes of micronutrients being close to that of actual intakes whilst reported intakes of fat, salt and sugar would be underreported to a greater extent than energy. Any attempt to adjust the data for low reported energy intake would only increase such discrepancies.

The extent to which underreporting was under-recording or under-eating was assessed by Goris *et al.* (2000). They used doubly-labelled-water to measure energy expenditure and asked subjects to complete a 7-day dietary record. Subjects were deemed to have under-recorded energy intake if energy intake was lower than energy expenditure but weight remained stable. Subjects were deemed to have under-eaten if energy intake was lower than energy expenditure and weight decreased. They found 37% of subjects underreported their habitual energy intakes of which 26% was due to a decrease in food intake during the study period and 12% was due to under-recording of food intakes. No selective omission of snacks was seen, but fat was selectively underreported. Foods consumed in the morning were found to be more accurately reported than those consumed later in the day. This may be as people tend to consume the same foods for breakfast each day, whereas there tends to be more day to day variation in the foods consumed later in the day.

Potential problems that may affect the validity of existing methods of estimating dietary intakes have been identified, and are discussed below.

- **Subject selection bias**

All dietary surveys are likely to suffer to some extent from subject selection bias. Subject selection bias is the phenomenon that those subjects consenting to taking part in a study are likely to be the more educated and more health conscious members of the population. The degree of subject selection bias is likely to depend on the intensity of the task the subject is being asked to perform along with the amount of time for which that task must be carried out. Berg *et al.* (1998) discuss that when participation in a project requires a great deal of subject commitment or divulging information of a sensitive nature then there is a risk that the response rate will be low. This will result in a biased sample and may result in dietary data which is not representative of the general population.

- **Altering food intake**

According to Heisenberg's uncertainty principle once you begin to measure something you change its properties by the process of the measuring. This statement holds true in measuring diet where the act of measuring changes the food intake of the individual being assessed. *'Recording of food intake, the knowledge that they will be interviewed about their food intake or being aware that their food intake is being observed may all lead to subjects altering their eating habits'* (Eck *et al.*, 1989). Gibson (1990) in discussing the food record method states *'a prime advantage is that the record keeper assumes an active role and may for the first time become aware of personal food habits and assume responsibility for them'*. A major concern is that this new awareness of their food habits may lead to changes in dietary intake and therefore the record will not reflect habitual intake. Macdiarmid and Blundell (1997) asked subjects to keep a 7-day weighed record and interviewed the subjects about their experiences. Almost half of the respondents admitted to changing their eating habits during the recording period. Around 53% of the people admitting to altering their diet said they did so due to being more conscious of what they were eating.

The burden of recording diet may be one factor which leads subjects to reduce or alter their usual intakes (Howat *et al.*, 1994). Subjects may alter their diet to facilitate weighing, consume foods which come in pre-weighed amounts or not eat snacks as the burden of weighing exceeds the desire for food. Macdiarmid and Blundell (1997) found 47% of subjects admitting to altering their diet during a 7-day weighed intake stated facilitating recording as their reason for change. In another study using the 7-day weighed inventory method, subjects admitted to altering their normal diet in order to facilitate the weighing of foods, and omitting or simplifying some measurements (Livingstone *et al.*, 1990). Vuckovic *et al.* (2000) found subjects altered their food intake by eating simpler foods, foods with pre-determined portion sizes and packaged foods, fewer snacks and not eating out, in order to make the task of recording simpler. These changes occurred despite the fact that the subjects had been specifically instructed to maintain their normal diet.

People may alter dietary intake to provide what they perceive to be a better or correct response. Hebert *et al.* (1995) suggest that knowledge of nutritional guidelines among the general public means self-reports of dietary intake are particularly vulnerable to what they term 'social desirability bias'. Subjects may eat more healthily during recording periods either consciously or sub-consciously and may forget food items or misjudge the quantities of foods consumed (Berg *et al.*, 1998). Women may be more prone to social desirability bias compared with men (Hebert *et al.*, 1995). Vuckovic *et al.* (2000) asked subjects to complete a 7-day weighed dietary record and measured TEE using DLW. They then conducted focus groups during which subjects were questioned concerning their experiences of completing the food record. Subjects admitted to being concerned about the researcher's perceptions of their diet and to altering their diet to be more healthy.

Such changes in diet may not be detected by the usual procedure for excluding dietary intakes deemed invalid, such as EI:BMR cut offs for underreporting. The group admitting to altering their diet to facilitate weighing had a higher EI:BMR than those claiming to have reported their intake accurately (Vuckovic *et al.*, 2000). Macdiarmid and Blundell (1997) state that whilst biomarkers, such as DLW and urinary nitrogen, are useful in detecting people who have underreported foods consumed they cannot detect individuals who have altered their diet.

- **Selective reporting**

A fatigue effect with the number of foods reported reducing as the recording period progresses has been seen with adult women (Oltersdorf *et al.*, 1999). Women underreported their energy intake by about 17% and intake of 7 out of 9 nutrients was lower on the last day of recording compared with the first. The number of food components, food items and snacks also decreased as the recording period went on. Subjects completing a 7-day weighed inventory commented on the difficulty of maintaining motivation for the full measurement period (Livingstone *et al.*, 1990). Berg *et al.* (1998) found a fatigue effect with children aged 9-14 years reporting consuming significantly fewer foods during the last 2 days of a 7-day record compared with the first 2 days. The authors note that there was some evidence that those people reporting lower energy intakes recorded having fewer snacks. It may be that this was a genuine dietary pattern or it may be that the snacks were eaten but not recorded or not eaten due to the burden of recording. In the study by Macdiarmid and Blundell (1997) using a 7-day weighed inventory subjects admitted to not recording all snacks consumed. Subjects may consciously or sub-consciously forget unhealthy food items or misjudge the quantities of foods consumed (Berg *et al.*, 1998), overestimating the quantities of healthy foods consumed and underestimating the quantities of unhealthy foods, consumed a phenomenon known as 'optimistic bias' (Arens, 1998).

- **Food composition tables**

In addition to the problems with obtaining the required information from subjects there are the limitations of the method used to translate reported food intakes into nutrient intakes. The nutrient values in food tables are means for that food obtained by conducting chemical analysis on a number of different samples of each different food type under investigation. The number of samples differs for each food. The nutritional value of foods is variable and may depend, among other things, on the type of soil in which the food was grown, the production methods used and the way in which the food was stored, prepared and cooked (Paul and Southgate, 1978). For some nutrients the food tables are incomplete. Almost all dietary assessment methods rely on the food composition tables as collecting duplicate diets and chemically analysing each food for each nutrient is neither a financially nor practically viable option for most studies of diet. The food composition tables allow a reasonable estimate of dietary intake at a much reduced cost.

Assessing the diets of children is further complicated by the constant development of new foods. New foods present a challenge to the researcher since they may not be familiar with the food but also because such foods will not be included in existing nutrient composition tables.

Summary

- There are no valid and reliable methods for children to self record their dietary intake. Indeed, it is arguable whether such methods exist for adults.
- The use of bio-markers have resulted in the discovery that underreporting of energy intakes is a common problem.
- In children underreporting of energy intakes increases with increasing age.

Sources of error in dietary assessment include:

Subject selection bias – people agreeing to take part in a dietary survey are commonly the more motivated and health conscious members of the population.

Altering food intake – Subjects may change their food intake to be more healthy or to facilitate recording.

Selective reporting – Subjects may mis-report food intake to report a diet which is perceived to be more healthy, due to fatigue or may omit snacks.

Food composition tables – The nutritional value of foods is variable and the use of average compositions in place of chemical analysis introduce a further source of error.

Nelson (2000b) discusses that the resulting inaccuracies in dietary data from all these sources of error can lead to incorrect ranking of individuals intake of a particular nutrient or incorrect classification of an individual in comparison with recommended intakes. Incorrect ranking of individual intakes tends to attenuate the relationship between diet and disease whereas the individual's nutrient intake being incorrectly classified as being insufficient or sufficient may result in either an intervention where none is required or a dietary deficiency going untreated.

2.5 Assessing food portion size

2.5.1 Food portion size assessment with adults

In order to assess nutrient intake it is necessary to obtain a measure or estimate of portion size for each food consumed. In dietary surveys food portion sizes may be weighed using scales, estimated by the subject or by the researcher or average portion sizes may be assumed. National dietary surveys using weighed intakes have been used to produce average adult portion sizes of various foods to aid the researcher in portion size estimation (Ministry of Agriculture Fisheries and Food, 1993). Lewis *et al.* (1988) have described the error associated with assuming an average portion size; they state *'using an imputed serving size based on age alone masks variations in intake'*. Frequency methods that employ a standard portion size are suitable only for ranking individuals by mean intake of food items and provide imprecise measures of nutrient intake. Average portion sizes cannot substitute for quantitative measurements where individual intakes are of interest (Slattery *et al.*, 1994). Portion size can be measured, but weighing may influence dietary intake as either consciously or sub-consciously the respondent reduces or alters their intake to avoid having to weigh the food (see Section 2.4.5).

Recent advances in technology have been applied in dietary methodology to facilitate self-reporting of diet by subjects. Food scales have been developed in an attempt to make the weighed intake simpler for the respondent to complete. PETRA (portable electronic tape recorded automatic) scales (Cherlyn Electronics Ltd. Cambridge) are fitted with a tape so that the subject can say what a food is as it is put on the scales and the weight and audio data are recorded. PETRA scales have been used to collect 7 day weighed intakes from 12-year old school children (McNeill *et al.*, 1991). In this study the authors chose PETRA scales as they believed the children would find it easier to record spoken rather than written information. They did however see evidence of a decline in interest over the recording period with 65% of children completing the records satisfactorily for at least 3 days but only 30% of the subjects completing 7 days satisfactorily.

As an alternative to weighing all foods eaten a number of methods of measuring dietary intake rely on subject's estimates of portion size. Subjects may be asked to estimate portion size using household measures for example slices of bread, cups of rice or spoons of sugar. Alternatively tools are available to assist the subject with estimating portion size. These include food photographs, food replicas and food models. Food photographs are a series of pictures of food taken on a standard size plate which subjects can use to describe the quantities of food eaten. Food photographs are particularly useful as they can be made to represent a range of portion sizes and food types and are easy to carry or can be mailed to respondents (Lucas *et al.*, 1995). Food replicas are three-dimensional models representing specific foods; there is often only one portion size for each food. Food models on the other hand do not represent specific foods but are a variety of different three-dimensional shapes of sizes which can be used to describe the quantities of a number of different foods (Cameron and Van Staveran, 1988).

Robinson *et al.* (1997) state that the use of food photographs as an aid to estimating food portion sizes does improve accuracy. They have also been shown to improve estimates of the nutrient content of meals (Nelson *et al.*, 1996). In a review of previous studies Nelson also concludes that photographs are of benefit in helping subjects to assess portion size but states that it is inevitable that some inaccuracies will remain (Nelson *et al.*, 1994b). In a study comparing the use of food photographs and household measures by 48 adults, from 18 year olds to over 65's, no significant difference was seen in the accuracy of portion size estimations and no significant difference in intakes of protein, energy, percentage energy from fat or percentage energy from carbohydrate (the only dietary parameters examined). However 75% of the subjects preferred the photographs compared with only 10% for household measures (Cannings, 1996). The importance of aids to portion size assessment is not fully appreciated and gaps in knowledge about their validity remain (Cypel *et al.*, 1997). Buzzard and Sievert (1994) comment that the impact of errors in food portion size estimation on reported food and nutrient intake is largely unknown. They called for more research into existing methods of estimating portion size in order to identify the sources of error so that they could be minimised.

2.5.2 Validation of methods for estimating food portion size with adults

In an attempt to describe the components of the error of portion size estimation from food photographs Nelson *et al.* (1994 a and b) conducted two experiments examining portion size perception and conceptualisation. Nelson defines perception as *'the ability to relate an amount of food that is present in reality to an amount depicted in a photograph'*; conceptualisation is described as *'a subject's ability to make a mental construct of an amount of food which is not present in reality'*.

- **Perception**

Nelson *et al.* (1994a) used a variety of foods that were selected to cover a range of characteristics of appearance that may have an influence on the perception of portion sizes from photographs. Ability to estimate portion size using a series of 8 photographs or a single average portion photograph was assessed. The portion sizes depicted in the photographs were based on the weights of foods recorded as being consumed in the National Diet and Nutrition Survey of British Adults (*Gregory et al.*, 1990). The average photo depicted the mean portion size reported for that food during the survey and the series of 8 photographs ranged from the 5th to the 95th centile of portion sizes reported for that food. The subjects were required to estimate the size of a portion of food which they had in front of them using the food photographs. Nelson *et al.* (1994a) found portion size tended to be under- rather than overestimated and that this was more pronounced when using the average photograph rather than the series of eight photographs. Subjects tended to overestimate the size of smaller portions and underestimate the size of larger portions a phenomenon known as 'flat slope syndrome'.

Lucas *et al.* (1995) also examined subjects' ability to estimate portion size using food photographs when the portions of food were present in front of them. They used photographs of only three portion sizes and presented foods which were the same weight as one of the photographs. As in Nelson's study small portions were seen to be overestimated and large portions were underestimated with a resulting regression towards the mean. No differences were found in subject's ability to estimate portion size with different food characteristics. Lucas *et al.* (1995) described the errors in portion size assessment which occurred as frequent but small with mean estimates being within 10% of the true value in around 50% of cases. They conclude that the photograph method improves portion size estimation compared with unaided estimates, although no un aided estimates were made during their study. This work did not examine the extent to which memory affects the ability to estimate portion size from photographs as all tests were conducted with the food in view. The apparent validity of the method in this study was likely to be increased due to the fact that the portion of food presented was identical in weight to the food in one of the three photographs. This condition is unlikely to be fulfilled when photographs are used in dietary assessment surveys.

- **Conceptualisation**

In a further study conceptualisation of portion sizes was examined (Nelson *et al.*, 1996). In this study subjects came to the study centre for a meal and served themselves a selection of foods. The researchers weighed both the foods as they were served and any leftovers. Five minutes after consuming the food the subjects were required to estimate the size of the portion they had consumed of each food using a series of 8 photographs. Again a regression towards the mean effect was reported with small portions being overestimated and large portions being underestimated. Men overestimated portion size more frequently than women, elderly subjects were also found to be more prone to overestimation of portion size. No trends in portion size estimation were seen with BMI. In general overestimation of portion sizes was found to be more common than underestimation and this translated into a trend for nutrient intakes to be overestimated. Differences were found in subjects' ability to estimate foods with different characteristics. The largest percentage errors were seen for mashed potato and spaghetti and the lowest for cornflakes.

Flat slope syndrome has been seen in many studies assessing subjects ability to estimate portion size (Faggiano *et al.*, 1992; Haraldsdottir *et al.*, 1994; Young and Nestle, 1995; Smith *et al.*, 2000). Faggiano *et al.* (1992) attributed their finding of the flat slope syndrome to asking subjects to estimate the size of portions which were out with the range of portions depicted in the food photographs. Eck *et al.* (1989) suggest that the errors of estimating portion sizes are cancelled out by the fact that higher intakes are underreported and lower intakes are overreported which is why many studies report good agreement at the group level but poor agreement at the individual level. As larger portions are often underestimated and smaller portions are often overestimated you might expect men, as they generally consume larger portions, would be more prone to underestimating energy intake. In fact it seems it is women who are more prone to underestimation (Howat *et al.*, 1994; Nelson *et al.*, 1996).

- **Perception, conceptualisation and memory**

One study which attempted to assess the ability of subjects to estimate their usual portion size as consumed in an every day environment was conducted by Haraldsdottir *et al.* (1994). Subjects completed a semi-quantative food frequency questionnaire with photographs for estimation of portion size and two 7-day weighed records within 6 weeks of completion of the FFQ. A comparison was made of the selected portion and the weighed portion. For almost all foods the relationship between the estimated and measured portion sizes was weak and ranged from a Pearson's correlation coefficient of r=0.22 for meat patties and salad to r=0.54 for boiled potatoes. The large day to day variation in portion size is given as a potential reason that people have difficulty in estimating 'usual' portion size.

Food photographs showing common household items such as spoons, plates and glasses of various sizes may be less useful than photographs of foods. Cannings (1996) found that whilst subjects were able to identify extreme spoon sizes such as the teaspoon and serving spoon they had problems identifying the intermediate sizes of spoons. This was confirmed more recently by Watson *et al.* (2000) who found, in addition to problems identifying the intermediate size spoons, subjects had difficulty identifying some of the plates and glasses.

Robinson *et al.* (1997) examined whether there was a difference in the ability of subjects to estimate portion size when foods were served compared with self-served portions. They examined two foods, mashed potato and Cornflakes as these were the foods found to be least and most accurately estimated in

Nelson's study (Nelson, *et al.* 1994a and b). They reported that the range of under- and overestimation was large for both foods but that ability to estimate portion size was not affected by whether or not the subjects served themselves the food. This finding may be of particular importance if children are the subjects as they are served most of the foods they consume.

A number of factors affect the accuracy with which portion sizes can be estimated using food photographs including the photograph's size, the number and range of portion sizes included (Nelson and Haraldsdottir, 1998b), the delay from eating to estimating and the visual characteristics of the food. Nelson *et al.* (1994b) found no difference in adult's estimates of food portion size using food photographs which were black and white compared with photographs depicting foods in colour. Use of a greater number of photographs has been found to result in greater accuracy and precision of portion size estimations (Nelson *et al.*, 1994b). This may be because the subject can choose the closest photograph rather than the more demanding task of explaining a portion size in terms of multiples or fractions of a photograph. Robson and Livingstone (2000) suggest a single average portion size food photograph may only be useful for ranking individuals according to nutrient intakes. The form of the food may also influence the accuracy of portion size estimations, with solid foods being estimated most accurately and amorphous or liquid foods being estimated least accurately (Howat *et al.*, 1994). In addition Howat *et al.* (1994) suggest perceptions of recommended portions sizes affected the portion size reported. Women in their study underestimated energy intake compared with TEE measured using DLW, but overestimated portion sizes of foods in a test situation where the food was not consumed. This could be due to underreporting of portion sizes consumed due to societal pressures as Howat suggests or may be due to omitting certain foods from the record either to facilitate recording or again due to societal pressures (Section 2.4.5).

- **Comparison of food photographs with food models and household measures**

Food photographs have been compared with food models and household measures (Rutishauser, 1982). University students were asked to use the three methods to estimate the weights of pre-weighed portions of foods. Household measures tended to result in an overestimation of portion size whereas there was a tendency towards underestimation with both the food photographs and the food models. The household measures method resulted in greater variability in estimates of portion size than either of the other two methods. Another study examined subjects ability to estimate the sizes of portions consumed under free-living conditions by asking subjects to keep a one-day weighed record and to attend a 24hr recall the following day (Pollard *et al.*, 2000). The weights of foods recorded in the weighed record were compared with estimates using household measures or from food photographs at the 24hr recall. At the group level estimates using food photographs were more precise around the mean and the mean estimates using photographs were closer to the actual weight than the mean estimates using household measures. Subjects found it easier to use food photographs than household measures for the majority of foods. Most of the portion size estimates were within plus or minus 20% of the weight reported in the weighed record.

Welten *et al.* (2000) conducted 3-day records with estimated portion sizes using household measures with adults between the ages of 20 and 80 years. The intention was to exclude those records with missing portion sizes. Only 6% of men and 3% of women returned 3-day records in which no portion sizes were missing. It was therefore decided to treat them as 1-day records, however 87% and 93% of the one day records had missing portion sizes from men and women respectively. Of all foods recorded 22% of foods recorded had no estimate of portion size. A comparison of the complete records with standard portion sizes found the use of standard portions resulted in significantly lower intakes of both energy and nutrients. Food photographs and food models may yield more complete records as the estimation of portion size is generally conducted in an interview situation. When household measures are used however subjects record both the amount and type of food immediately before or after eating.

Kirkaldy-Hargreaves *et al.* (1980) examined the validity of four different methods for estimating portion size: food replicas, food photographs, food models and life size 3-dimensional drawings of the food models. Validity was assessed by calculating the 95% confidence interval for the mean estimated weight of each food under investigation and noting whether the true weight lay within these values. Validities ranged from 58% for the food replicas, 60% for the drawings of the food models, 60% for the food models to 63% for the food photographs.

- **Computer based portion size assessment**

Gines (1989) examined the application of a computer package for portion size estimation. The package had pictures of food which the subject could increase and decrease in size. Subjects were shown an orange and were asked to indicate when the computer graphic was the same size as the actual food. Subjects were also asked to give a verbal estimate of the size of the food. The actual food size was compared with both the computer aided and the verbal estimates by the subjects. The computer aided estimate was found on average to be 98.5% of the actual size and the verbal estimate 109% of the actual size. This difference was statistically significant. No significant difference in the portion size estimate was seen whether black and white or coloured pictures were used. One advantage of a computer based portion size assessment tool is its novelty. Subjects are likely to find computer based methods entertaining and therefore motivation should be maintained throughout the interview. Such methods also have the potential for automated data entry.

- **The effect of training on subjects ability to assess portion size**

Training subjects in the use of portion size assessment aids has been shown to improve estimates of portion size using that aid (Howat *et al.*, 1994), but the time taken to train individuals may negate the benefit of using estimated portion size in place of weighing of foods. Training may improve estimation of portion size for only a sub-set of foods rather than all foods (Bolland *et al.*, 1988; Vuckovic *et al.*, 2000). Bolland *et al.* (1990) comment that they could not identify the distinguishing characteristics of those foods for which estimation is improved. The benefits of training subjects in estimating portion size may be short lived. Bolland *et al.*, 1990) found whilst training improved assessment of portion sizes, the errors seen in portion size estimation were still quite large. The improvement was starting to reduce by 4 weeks after training.

As evidenced by the work discussed above many adults have difficulty accurately estimating portion size (Webb, 1988; Guthrie, 1984). Estimation of the size of an object which is no longer in view is a very complex cognitive task, which may be beyond the capabilities of some adults and of younger subjects.

2.5.3 Estimation of food portion size with children

As with adults where children are the subjects of dietary assessment, portion sizes must be either weighed or estimated. For adults average portion sizes are available (Ministry of Agriculture Fisheries and Food, 1993), but no equivalent data exist for children. Work for the publication of average portion sizes for children based on the NDNS survey (Gregory and Lowe, 2000) is currently underway at the University of Dundee. Evidence from work with adults suggests that food photographs may be of use in improving portion size estimation but there has been limited research into the accuracy with which children can use portion size assessment aids to estimate the amount of foods they consume. Frobisher and Maxwell (2003) compared children's ability to estimate food portion sizes with that of adults. The subjects were asked to serve themselves with their usual portion size of nine food items which were then taken away and weighed. The subjects where then asked to give a verbal description of the portion size of each food (small, medium or large) and were asked to identify the portion size of the food using the photographic atlas of food portion size (Nelson *et al.*, 1997). Frobisher and Maxwell (2003) found, as might be expected, that there were greater errors with children estimating portion sizes using both descriptions and food photographs compared with adults. There was a tendency for food portion sizes to be overestimated by both adults and children. Lytle *et al.* (1993) observed school lunches of 8 year old children and recruited parents to observe and record foods consumed at home. Children's reported intakes in a 24hr recall using food models to estimate portion size were compared with observations. The children were found to be able to report accurately the type of foods they had eaten but found it difficult to estimate portion sizes. There were significant differences between observed and recalled portion sizes, but it should be noted that this study compared the child's estimate with the observer's estimate rather than the actual weight of the food consumed. Crawford *et al.* (1994) also used observer assessments of portion size to validate 9-10 year old girls estimates of portion size, using three different dietary methods all of which included an estimate of portion size using 'standard measurement aids' although the nature of these aids was not specified. Children were found better able to estimate portion size during a 24hr recall than during an FFQ or dietary record interview. Crawford *et al.* (1994) suggest this difference is due to the short time interval between consuming and reporting the food. There is some evidence that parent/guardian estimates of their children's portion sizes using food photographs and food models are no better than the use of an average portion (Kuehnemann *et al.*, 1994). However this may be due to parents not being aware of the amounts of foods their child eats out of the home.

A number of factors may influence the perception of food portion sizes. In assessing children's perception of the size of non-food items Blum (1957) found the value the child held for an item affected its perceived size. Children may remember portion sizes of preferred foods to be larger and disliked foods to be smaller than the actual amount consumed (Gibson, 1990). Beams (1954) found that on average liked foods were seen as significantly larger than disliked foods. During these trials however the children were not asked to eat the food. It may be that the reverse would be true had the child consumed the food with the child thinking they had eaten more of the food they did not like. Hunger may also have an impact on portion size assessment. Beasley (2003) found people estimated their usual portion sizes of foods to be larger when they were hungry compared with when they had just been fed. A food's colour may also have an impact on the estimation of portion size. Toshiaki (1955) found a trend for white objects to be overestimated compared with black objects. Light colours were overestimated whilst dark colours were consistently underestimated. In terms of estimation of food portion size this may result in an overestimation of the size of foods which are light in colour and an underestimation of the size of foods which are dark in colour.

As is the case with adults, training may improve children's ability to estimate portion sizes. Children trained in estimating food portion sizes using household measures showed a decrease in estimation error compared with a control group, however the error for many foods remained large (Weber *et al.*, 1999).

Cypel *et al.* (1997) called for more research into the use of new technologies in improving estimates of portion size. Chambers *et al.* (2000) state *'new aids should allow respondents to mentally, visually or physically resize the aid to meet specific needs.'* and suggest the development and use of computerised interviewing which allows the subject to resize and adjust the pictures of foods whilst instantaneously calculating and recording the portion size. Technology has allowed the development of a computer based food atlas (Horan *et al.*, 1994). This computer atlas consisted of colour photographs with up to 3 portion sizes for each food, however these could not be resized. The application of the computer atlas was compared with that of food photographs. The authors conclude that subjects found it difficult to estimate portion sizes using both the standard food photographs and the computer food atlas. The computer food atlas produced mean estimates which were closer to the actual weight of the food. However the standard food atlas had only one portion per food whereas the computer atlas had up to three, therefore this study did not compare like with like. Gines (1989) developed a computer based atlas in which the picture of food could be re-sized. Resizing the image may however prove a much more difficult task than merely selecting the most appropriate photograph, and may be beyond the cognitive abilities of young children. The resizing feature may also prove quite distracting for children who may focus on the resizing and forget the purpose of the task. Cullen *et al.* (1998) interviewed children of age 8 to 10 years concerning a computer based dietary assessment method and found images of mounds of cooked foods were preferred to measuring cups and containers with different level lines as an aid to portion size assessment. The children suggested for fruit, a picture of the whole fruit could be shown but they should have the ability to visually remove slices to indicate the amount eaten. A computer based aid to portion size estimation has the potential to maintain children's attention whilst being appealing to the teachers in that children gain computer experience. Any computer package should be engaging without being so much fun that the subject becomes distracted from the task of estimating portion size.

Livingstone and Robson (2000) comment that as yet the assumption that including an aid to estimating portion size will increase the accuracy of children's dietary reports has not been verified. Livingstone and Robson (2000) highlighted the requirement for methods of estimating portion size which are *'sensitive to the cognitive abilities of children'*.

2.5.4 Methods of assessing validity of portion size assessment methods

In assessing the validity of portion size assessment aids, the estimated weight of a food should be compared with the actual weight of that food. A comparison of nutrient intakes may result in greater apparent validity of the method as overestimation of certain foods may be offset by underestimation of others (Cypel *et al.*, 1997). Many researchers have employed correlation coefficients to assess the agreement between estimated and actual portion size, however Bland and Altman (1986) point out that the correlation coefficient does no such thing. Correlation does not measure agreement but measures the relationship between two variables such as for example diet and cancer. Whilst we might expect a strong correlation between these two variables we would certainly not expect the values to be in agreement. Bland and Altman (1986) argue that *'it would be amazing if two methods designed to measure the same quantity were not related.'* One method may give measures consistently five times higher than another method; the two sets of values would be perfectly correlated but would be far from in agreement. Bland and Altman (1986) propose a method of comparing the two values which involves plotting the difference between the two measures, in the case of portion size assessment the difference between estimated weight and actual weight, against the mean of these two measures. Ideally all the points would lie along the zero line indicating no difference between the two methods. The limits of agreement are calculated as the mean difference plus or minus 2 standard deviations (SD). As long as the limits of agreement are of little nutritional significance the method can be concluded to be valid.

It is important to ensure validation of the method to be used has been carried out in a population similar to the target population (Nelson and Haraldsdottir, 1998b). Just because a method has been shown to be valid in one population does not imply it is valid in all populations (Nelson and Haraldsdottir, 1998a), therefore portion size aids which have been validated with adults may not be appropriate for portion size assessments with children as the subjects. Robson and Livingstone (2000) suggest, for example, that food photographs which show only a single average adult portion of each food are unsuitable for use with children. The validity of portion size assessment aids in different age groups needs to be ascertained (Cypel *et al.*, 1997). Nelson *et al.* (1994b) state that *'memory will affect the precision of the conceptualisation'.* In children this is likely to be a concern. Even more importantly Baranowski and Domel (1994) describe size estimation as a *'highly skilled cognitive activity'*, one which is beyond the capabilities of many children. Thus the validity of aids to portion size estimation should be studied prior to their use in dietary assessment with children.

2.6 Cognitive development in relation to reporting diet and estimating food portion sizes

'The process of recalling and recording food intakes requires attention and perception, registration, storage and retrieval of daily events' (Blundell, 2000). Methods of measuring dietary intake in children need to be tailored to children's cognitive abilities. Piaget put forward the idea that young children have completely different thought processes rather than simply being less intelligent than adults and older children (Shaffer, 1999).

2.6.1 Memory and dietary reporting

Attention is noticing information. Baranowski and Domel (1994) discuss that if children do not attend to an item of food at the time of eating, then that food cannot be recalled during a dietary interview. Those items most commonly consumed at a meal are least likely to be attended to (Baranowski and Domel, 1994). Buzzard and Sievert (1994) discuss the lack of knowledge concerning the retention of information about food and eating by different age groups. They suggest younger children are likely to remember everything verbatim and that an inhibitory mechanism is likely to develop with age which allows unimportant information to be forgotten. Such an inhibitory process may reduce 'cognitive clutter'. Both being restricted to remembering things verbatim and the lack of an inhibitory process will contribute to cognitive clutter in younger children. This is likely to result in the retention of unimportant information which displaces more important information (Shaffer, 1999). In terms of retrieval from memory, young children have problems recalling information from memory on their own, that is they respond better to prompted recall than free recall. However children as young as two or three years old are able to reconstruct past events and think about or compare objects recalled from memory. It is often assumed that children are capable of conceptualising the relevant time frame for dietary assessments for example 24hrs, a week etc although this ability has not been established (Frank, 1994). Emmons and Hayes (1973) found children as young as six were aware of what yesterday meant.

2.6.2 Size perception and assessing portion size

Perception has been described as the interpretation of sensory input (Shaffer, 1999). Between 4 and 7 years of age children become more accomplished at classifying objects by size, shape and colour (Shaffer, 1999).

- **Size constancy**

Size constancy is the realisation that although an object appears smaller if it is further away it is actually the same size. Size constancy develops from the first year of life but is not fully developed until the child reaches 10 to 11 years of age. (Shaffer, 1999). Steinhmetz (1991) found children under the age of 7 perceived a photograph to be an exact replica of reality and concluded a highway shown in perspective became narrower and that elephants which were further away were smaller. Children of 8 years and older showed a clearer understanding of perspective. In terms of portion size estimation this may be relevant where food photographs are produced to be smaller than life-size.

- **Conservation**

Conservation is the ability to recognise that size or quantity remains the same when the appearance of the object changes (Goswami, 1998). The ability to conserve develops at around 7 years of age. Shaffer (1999) gives the example of a ball of playdoh which is flattened to form a disk. Whereas an 8 year old child is aware that the amount of playdoh remains the same, a five year old child would assume that there is now more playdoh as the disk covers more area. This has implications for portion size assessment. A specific example of how the ability to conserve relates to the estimation of portion sizes is that children younger than 6 or 7 will usually say that a tall thin container holds more liquid than a short broad container when both containers actually contain the same amount. Children younger than around 6 years old tend to interpret big to mean tall (Coley and Gelman, 1989). Young children can however be taught to conserve and can use this new skill on other conservation problems for which they have not been trained (Shaffer, 1999). Some researchers argue, however, that the presentation of the traditional task which is used to determine whether or not children have developed the ability to conserve may result in a false negative result. This is because the task involves asking the same question twice which may be taken to imply that the researcher would like the child to change their answer. Some researchers have presented the conservation task in a different way, which avoided asking the same question twice, and found children as young as 4 years old able to conserve (Goswami, 1998).

- **Reversibility**

Reversibility is the ability to undo an action by mentally doing the reverse of the action (Shaffer, 1999). This ability develops at around 7 years of age and allows children to mentally undo the pouring of a liquid from one container into another and imagine the liquid in its original container. The ability to perform this task would assist in the estimation of quantities of liquids consumed where the container in the set of models or photographs is different from the container in which the liquid was served.

Sera *et al.* (1988) examined children's knowledge about the size of two common items, buttons and plates with children of 2- and 4-years old. Whereas the 4-year old children's knowledge of the size of both items was good the 2-year old children did not perform well. The authors carried out a further study with the 2-year olds to determine whether they had better knowledge of the size of things for which size was important to the function. Shoes were chosen and it was found that the 2-year olds were very capable of selecting shoe sizes appropriate for themselves, their mother and their father. They conclude that when size is critical to the use of the object even young children can accurately represent the size. It may not be the fact that size is important to the function but rather the child's familiarity with the object that matters (Sera *et al.*, 1988). If this is the case children might be more adept in estimating the portion sizes of familiar foods.

Children of 3- and 4-years old have been found to be capable of performing relative judgement and using perceptual standards. Ebeling and Gelman (1988) found children of 2.5-years old were able to use both perceptive and normative standards. Normative size standards include for example a person's mental image of the size of an average apple. As discussed previously some of the cognitive processes required for the quantification of portion sizes, such as conservation and reversibility may not develop until a child is 7-11 years of age (Shaffer, 1999). Ebeling and Gelman's (1988) research suggests even very young children would be able to look at an apple presented to them and compare it to their normative standard to say whether the apple is small, medium or large for an apple. Their ability to use perceptual standards implies that the children would be able to look at an apple in front of them and say whether that apple was larger, smaller or the same size as another apple that is also in front of them. In terms of portion size estimation this suggests the child, at the time of consuming the apple would be able to judge whether the apple is small, medium or large. Depending on memory they may also be able to say whether the apple was larger or smaller than a model or photograph of an apple.

A greater understanding of children's perception of size related to food and the effects of various properties of the food including colour, form and the child's preference on perception of size is required. This knowledge can be used to improve children's ability to estimate portion sizes and to allow the development of tools which help children to estimate portion size more accurately. This in turn will reduce the respondent burden and may increase subject recruitment and compliance so resulting in more accurate and representative dietary data being collected.

2.7 Summary

The proven link between diet and disease along with the importance of diet during childhood for health in adult life necessitates that children's diets be monitored. Given that most dietary methods currently used in studies with children were designed for use in an adult population, there is a need to develop and validate new methods of assessing dietary intake aimed specifically at children. Methods for use with children need to be tailored to children's cognitive abilities, should require minimal literacy and writing skills and should not rely heavily on the child's memory. The issue of underreporting, a frequent problem in dietary studies where adults are the subjects, needs to be addressed. This may occur in children but for different reasons, such as memory and concentration span. Methods developed for use with children should be made as unobtrusive and as fun as possible to avoid a 'fatigue effect' and omission of foods or a temporary reduction in food intake due to the burden of recording. Overreporting may also be a concern with children feeling under pressure to report having finished all foods which they were served. Children should be reassured that the researcher does not mind them having left foods. In addition it should be stressed that the child's diet is not being judged and it is the normal diet which is being investigated to minimise overreporting of foods believed to be healthy in an attempt to please the researcher. This should also be stressed to the child's parents who may wish to appear to be providing a healthy diet for their child.

The assessment of portion sizes is a particular problem. Many adults find it difficult to estimate portion sizes and the methods which are used as portion size assessment aids with adults may be inappropriate for use with children because of their different cognitive abilities. Research into the most accurate method of assessing portion size with children is required along with investigation into the length of time portion size information is retained by young children.

As there is no dietary assessment method used with adults which gives a perfect measure of habitual diet, dietary assessment methods for use with children should aim for a validity approaching that of adult methods.

2.8 The aims of the study

- To develop methods for assessing dietary intake designed specifically for completion by children of primary school age (age 4-11 years).
- To assess the relative validity of these methods and make any necessary refinements.
- To apply these methods in establishing the effectiveness of a dietary intervention.
- To assess the validity of current adult methods of assessing the size of portions consumed, for use with primary school children and, if appropriate, to make suggestions for possible alternative methods.

Chapter 3 Pilot study

3.1 Introduction

A pilot study was conducted in two Newcastle schools to develop and test methods of assessing dietary intake in primary school children. Once developed these methods were to be used in the evaluation of the impact of a fruit and vegetable intervention, on children's dietary intake. The methods needed to be easy enough for the child to complete while they were at school or otherwise away from their parent or guardian. The methods were developed, pilot tested and where appropriate refined prior to commencement of the fruit and vegetable intervention study.

3.2 Aim

The aim of the pilot study was to develop and test two methods of assessing the impact of a fruit and vegetable intervention at the group level. One method was to be a quick and economical method of assessing fruit and vegetable intake in a large number of children. It needed to be easy to complete to ensure a high completion rate. This method would assess the effectiveness of the intervention in increasing intakes of fruit and vegetables and would be completed at three time-points during the academic year.

The second method was required to assess total nutrient intake in a sub-sample of the study population. It would be completed at two time-points during the academic year, at the beginning of term before the implementation of the intervention and towards the end of term after all the curriculum material for the intervention had been delivered. This method would be used to determine whether there were any effects, positive or negative of the intervention on energy or nutrient intakes. Both dietary methods were intended to give an estimate of group intake rather than that of an individual.

3.3 Development of the methods of dietary assessment

An extensive review of the literature was conducted (See sections 2.3.3 to 2.4.1) to establish which methods of dietary assessment were appropriate for use with children. Methods of measuring total dietary intake and monitoring of fruit and vegetable intake with both adults and children were included in the review (See section 2.3). Particular attention was paid to methods used with children of primary school age. From this review it was decided to use two methods:

- A food diary designed to measure total dietary intake
- A food record designed to measure intake of fruit and vegetables only

The food diary and interview method was based on a 24hr recall assisted by a record of food intake used by Lytle *et al.* (1994). The food record was a novel method designed to be quick and simple to complete. Both methods were modified for children so that the write and draw technique could be used. The write and draw technique involves the child being asked to draw a picture and then label it, with adult help if required. Oakley *et al.* (1995) describe the use of drawings to collect data from primary school children as *'a valuable research tool'.*

3.3.1 Food record

To measure intake of fruit and vegetables a food record was developed. The food record was designed with three pages per day covering morning, afternoon and evening (Appendix 1). The purpose of the food record was to measure intake of fruit and vegetables only but, to avoid recording bias, categories for bread and biscuits were also included. A picture dictionary covering the most common foods in each category was provided so that the younger children could identify the item eaten and transcribe the word (Appendix 2). Following development these tools were pilot-tested with children of primary school age.

3.3.2 Food diary

The food diary method was selected to be the measure of total dietary intake. The food diary usually has spaces for the subject to list all foods consumed, the time it was eaten and sometimes the weight of each food. The method was modified for use with primary school children by including six pages per day, three for writing a description of the foods eaten in the morning, afternoon and evening, opposite three with spaces for the child to draw their food (Appendix 3). Parents were asked to assist their children in completing the food diary. The intention was that parents would help their child to write down all foods eaten, using the child's drawings from throughout the day as a prompt for foods eaten outside the home. This was used in conjunction with an interview during which a photographic atlas of portion size (Appendix 4) was used to determine amounts of foods eaten (Nelson *et al.*, 1997). The atlas depicts photographs of increasing weights of foods and covers 78 different types of food. The food atlas was designed for use with adults and no such tool was available designed specifically for use with children. In order to make the atlas more suitable for use with children only the four smallest portions of the 8 available in the food atlas were used for the younger children in the study, unless the child specified that the amount they ate was larger than all of the portions shown. It was decided the diary would be completed over 3 days as a number of authors have seen a fatigue effect with both adults and children reporting dietary intake less accurately towards the end of a 7-day record of intake.

3.4 The schools

Ethical approval for the study was obtained from the Joint Ethics Committee, Newcastle and North Tyneside Health Authority (ref 107/99). Two primary schools in the Newcastle area were recruited to take part in the pilot study. The schools were Cragside primary school (School 1) and Kingston Park primary school (School 2). The schools were selected to include children from a range of socio-economic backgrounds, however compared with NDNS (Gregory and Lowe, 2000) the percentage free school meal entitlement for both schools is low, 8% compared with 14%. Table 3.1 shows the number of children attending each school and free school meal entitlement.

Table 3.1 School roll and free school meal entitlement

School	School roll	% roll entitled to free school meal	% take up of free meal entitlement
Cragside primary	395	8	93
Kingston Park primary	422	8	83

Initial contact was made via a letter to the head teacher (Appendix 5). Both of the schools contacted agreed to take part in the study. This was followed up by a telephone call to establish interest and answer any questions the school had about the project. Finally a meeting was arranged with the head teacher to discuss the methods to be used in the study, the letters to go out to parents and the practicalities of running the project around the school day.

3.5 The subjects

Children were recruited from year groups 1 and 6 that is aged 5-6 and 10-11 years respectively. A letter (Appendix 6) detailing what the study involved was sent to the parents of all children in the relevant year groups and parental consent was sought for participation in the study. Children and parents were asked to consent to completing both a food record and a food diary for the same three-day period. All children returning completed consent forms were asked to complete a food record that was designed to measure intake of fruit and vegetables. In addition 10 of the children consenting from each year group were randomly selected to keep a concurrent food diary.

3.6 Distribution of the food records and food diaries to the children

At the beginning of the study all participating children from a year group were seen together and the food diaries and food records were distributed. Detailed verbal instructions on completing the two methods were given. A1 size examples of completed diaries and records were used to illustrate how they should be filled in and any questions were answered. For the food diary it was stressed that all foods and drinks, even water, should be recorded. For the food record it was explained that any foods eaten which fell into the four food groups should be recorded. The children were instructed to include any foods they were unsure about, as the researcher could choose to ignore foods that were recorded but should not have been, but could do nothing about foods that should have been recorded but were not. Children were also assured that their diet was not being judged.

In addition to the verbal instructions given to the child, written instructions were included both on the food diary and food record and in an instruction letter to parents (Appendix 7). In the letter to parents it was also stressed that the quality or content of their child's diet was not being judged.

Table 3.2 shows the timing of the data collection for the pilot study. All data collection took place during two weeks in June of 1999.

3.6.1 Food record

The food record was to be completed for a three-day period and then returned to school. The foods reported in the record were not quantified and no interview was conducted around the food record. To try and ensure all completed records were returned, reminders were sent home with children who did not return their record within two days of completion.

3.7 Data collection

Table 3.2 Timetable for the pilot study

	School 1	School 2
Letters sent out to schools	Day 1	Day 1
Initial school visit	Day 19	Day 21
Recruitment letters to parents	Day 33	Day 40
Consents collected	Day 51	Day 58
Instruct children on methods	Day 54	Day 61
5-6 year olds start recording	Day 55	Day 62
10-11 year olds start recording	Day 54	Day 61
5-6 year olds interviews	Day 56	Day 65
	Day 57	
	Day 58	
10-11 year olds interview	Day 55	Day 64
	Day 56	
	Day 57	

School 2 was also visited on the Day 62 to photograph and weigh school meals.

3.7.1 Food diary

The children keeping food diaries were asked to attend an interview during which their diaries were checked item by item. The interviewer tried to ensure that all items of food and drink consumed were entered into the diary and that all necessary information to identify unfamiliar foods was recorded. Portion sizes were quantified using the photographic atlas of food portion sizes (Nelson *et al.*, 1997) (see Section 3.3.2 and Appendix 4). In one school, children were seen on three consecutive days to review the previous day's intake. In the other school only one interview per child was conducted covering the full three days of intake. This was done to assess the frequency with which the children would need to be seen in order that the information was still available for recall.

In one school children's school dinners and packed lunches were photographed to allow a comparison of the foods reported with those actually consumed.

In order to compare children's estimates of portion size using the food photograph atlas (Nelson *et al.*, 1997) with the amount of food served at school dinner an average portion of each of the foods selected by the children participating in the study who ate a school dinner was determined by weighing two or more examples of each food which were weighed along with individual children's leftovers.

3.7.2 Feedback

A feedback form (Appendix 8) was included with the instructions to parents letter. This was designed to collect information on the ease of use of the food diary and food record methods along with any suggestions for improvement. Both parents and children were encouraged to record their comments.

3.8 Data Handling

3.8.1 Coding

All data collected from each child were coded for entry into an ACCESS database that had been specially developed for the study. In addition to areas for entering the food diary and food record data the database contained information on the child such as name, school class, gender and date of birth.

Each item recorded in the food diary was assigned a food code from the food composition tables (see Section 3.8.2) and this code was entered along with the date, day of survey, time of consumption, meal type and the origin of the food e.g. home, school, friend or relative's house or elsewhere.

For the food record each fruit or vegetable item consumed was assigned a food code from the food tables and this code was entered along with the date, day of survey and the name of the fruit or vegetable consumed.

3.8.2 Food codes and food composition tables

McCance and Widdowson's 5th edition and all supplements were used to assign a food code to each food (Holland *et al.*, 1988; Holland *et al.*, 1989; Holland *et al.*, 1991; Chan *et al.*, 1992; Holland *et al.*, 1992a; Holland *et al.*, 1992b; Holland *et al.*, 1993; Chan *et al.*, 1994; Chan *et al.*, 1995). The supplements were used in preference to the 5th edition to ensure that the most up to date dietary analyses were being used. Only where no suitable food code was available from the supplements was a food code from the 5th edition assigned. A single table containing all McCance and Widdowson's food tables was created within the ACCESS Database and a look up form created to facilitate coding. The look up form was also linked to a table containing the weights of foods relating to the photographic atlas of food portion sizes (Nelson *et al.*, 1997).

3.8.3 Data checks

Only diaries or records that had been completed for the full three-day period were included in the analysis.

Input validation criteria ensured food codes entered were within the range of food codes which exist. An upper limit on the weight which could be entered for each food was also set at 568g.

The frequency of use of each food code was listed and codes used infrequently (less than 10 times) were checked against the original records. Maximum and minimum weights for each food were examined to look for errors. The data were further checked for coding errors by checking the list of foods entered into the database for any obscure foods such as 'conger eel, raw' or any unlikely weights such as 25g of salt. Where any discrepancies were found reference was made back to the original diary or record and the data were corrected accordingly.

3.9 Data analysis

3.9.1 Food diary

Queries within the database were designed to produce mean daily intakes of energy, fat, carbohydrate and protein along with selected micronutrients for each child. For each age group the mean and standard deviation for intakes of energy, fat, carbohydrate and protein and selected micronutrients (iron, calcium and vitamin C, retinol equivalents and thiamin) were calculated. The micronutrients were selected to allow comparison with the nutrient intakes reported in the Diets of British School Children survey, which used a 7-day weighed inventory (Department of Health, 1989). The calculated micronutrient intakes were then compared with the means from the national survey (Department of Health, 1989) by independent t-test.

For the children who had their school dinner or packed lunch photographed (see Section 3.10.2) the food diaries were examined and a comparison of the foods reported and the foods actually consumed was conducted. The number of items missing, that is eaten but not recorded, and the number of 'phantom items', that is not eaten but recorded, were determined.

Unfortunately only two of the children who completed food diaries and attended the interviews had a school dinner during the data collection period. This was due to most of the children in both year groups (both consenting and non-consenting) opting to bring in a packed lunch. Whereas average portions served at school meals could be obtained from the catering staff for school dinners it was not feasible to weigh the items in a child's packed lunch. Therefore no meaningful statistical analysis could be performed on the data comparing the children's estimates with the weight of the average portion served.

3.9.2 Food record

For each age group the mean intake of fruit, vegetables, and fruit and vegetables in terms of frequency was determined. For those children completing a food diary in addition to the food record the frequency of intake of fruit, vegetables, and fruit and vegetables from the food diary was also calculated. The number of discrepancies between the food diary and the food record were determined.

The number of portions in the food diary was subtracted from that in the food record so a positive value represented an overestimation of fruit and vegetable intake using the food record. A one-sample t-test was conducted to assess whether the difference in the number of portions recorded between the two methods was statistically different from zero.

3.10 Relative validation of the methods

3.10.1 Food record

The relative validity of the food record compared with the food diary was assessed, the food diary being the more established method (see Section 2.3.2). For those children completing both methods, the number of portions of fruit, vegetables, and fruit and vegetables recorded by both methods were determined. The difference in the number of portions recorded in the food record and the food diary was calculated. The food record was checked against the concurrent food diary in order to identify where discrepancies occurred. This was done to identify potential problems which may occur, for example, fruit squashes recorded as fruit juice.

3.10.2 Food diary

The mean nutrient intakes for each age group, measured by the food diary were compared with mean daily intakes from a national survey of school children (Department of Health, 1989). This was to allow comparison of the values obtained with nationally representative data of nutrient intakes for children of this age (902 boys and 821 girls aged 10 to 11 years). At the time of the study, in 1999, no national or large scale dietary surveys of children aged 5-6 years were available for comparison as this was prior to the publication of the National Diet and Nutrition Survey: young people aged 4-18 years (Gregory and Lowe, 2000). Although the data could be compared with the NDNS data retrospectively, judgements on the performance of the food diary were made using the data which was available at that time. Retrospective comparisons of the food diary data with the NDNS data are included in Appendix 9. The mean energy and micronutrient intake of the 5-6 year old children was compared with the estimated average requirement (EAR) from the dietary reference values (DRVs) produced by the Department of Health (Department of Health, 1991).

Children consuming school dinners and those bringing a packed lunch had their dinner photographed before and after eating (Appendix 10). These photographs were used to verify that the foods reported in the food diary and interview matched those foods actually consumed. The number of missing and 'phantom' foods was recorded. Small scale validation of the food photographs was also undertaken. The weight of a 'usual portion' for each of the foods served by the school canteen staff was obtained to compare with the weight of food the child selected using the food photographs.

3.11 Results of pilot study

3.11.1 The subjects of the study

Table 3.3 Number of children consenting to taking part in the study

School	Year	Age years	No. children targeted	No. consents (%)
School 1	1	5-6	60	30 (50%)
	6	10-11	60	31 (52%)
School 2	1	5-6	29	15 (52%)
	6	10-11	24	16 (67%)
Total			173	92 (53%)

Table 3.3 shows the consent rate of the different age groups from school 1 and school 2. The overall consent rate was 53% with 92 children consenting to take part out of 173 children approached. The consent rates in both schools were slightly higher for the older children.

Table 3.4 Age and sex of the children consenting to take part

School	Year	Age years	Male : Female	Age years (mean±sd)
School 1	1	5-6	17 : 13	6.3 (0.29)
	6	10-11	16 : 15	11.2 (0.26)
School 2	1	5-6	5 : 10	6.0 (0.25)
	6	10-11	5 : 11	11.0 (0.21)
Total			43 : 49	9.7 (9.87)

Table 3.4 shows the age and sex of those children consenting to take part in the study. Of the 92 children consenting to take part in the study 46% were boys. Of the Year 1 children taking part in the study 48.9% were male and 51.1% were female. In Year 6 the percentage of females was slightly higher, 44.7% were male and 55.3% were female. The mean age of the Year 1 children was 6.3 years, the mean age of the year 6 children was 11.1 years.

Table 3.5 Number of children completing the dietary assessments

School	Age	Food record completion (%)	Food diary completion (%)	Interview completion (%)
School 1	5-6	24 of 30 (80%)	10 of 11 (91%)	26 of 33 days (79%)
	10-11	21 of 24 (88%)	10 of 10 (100%)	30 of 30 days (100%)
School 2	5-6	11 of 15 (73%)	9 of 10 (90%)	9 out 30 days (30%)
	10-11	12 of 16 (75%)	9 of 10 (90%)	24 of 30 days (80%)
Total		68 of 85 (80%)	38 of 41 (93%)	89 of 123 (72%)

Table 3.5 shows the numbers and percentage of children completing the food records, food diaries and the food diary interviews. Of those children consenting to take part, 71 completed the study, an overall completion rate of 77%. Completion rates for the food record were slightly lower than for the food diary. This may be attributable to subjects being required to complete both the food record and the food diary method. As the food diary method involves recording all foods and drinks consumed it may be that these subjects, or their parents, did not see the value in completing both methods.

The completion rates for both the food diary and the interviews were high. The low completion rate for the interviews by the year 1 children in school 2 is due to a number of parents keeping the diaries at home during the recording period. This resulted in some of the first interviews having to be abandoned as no record of the child's intake was available upon which to base the interview.

3.12 Accuracy of the dietary assessment methods

Table 3.6 A comparison of the macronutrient intakes of children completing the food diaries with data from estimated average requirements[1] and a national survey[2]

	EAR[1]	Age 5-6 (mean±sd)	DoH study[2] (mean±sd)	Age 10-11 (mean±sd)	P[3]
Number		19	1723	19	
Energy MJ	7.0	7.9 (1.1)	8.2 (1.6)	7.1 (1.1)	<0.01
% Energy Fat	<35	34.5 (3.9)	37.6 (3.3)	33.8 (5.0)	<0.01
% Energy Carbohydrate	>50	52.3 (5.3)	50.4 (3.9)	53.0 (5.4)	<0.01
% Energy Protein	15	13.3 (2.1)	11.9 (1.6)	13.1 (2.3)	<0.01

1 EAR estimated average requirement for 5 to 6 year olds (Department of Health, 1991)
2 Intakes of 10 to 11 year old children taking part in the Diets of British Schoolchildren survey (Department of Health, 1989)
3 The p value given is the significance of the difference between the 10 to 11 year olds in the pilot study and the 10 to 11 year olds taking part in the Diets of British Schoolchildren survey (Department of Health, 1989)

For the 10-11 year old age group comparisons were made with data collected during the Department of Health survey in 1983 'The Diets of British school children' (Table 3.6) (Department of Health, 1989). This study used a 7-day weighed diary. The mean energy intake is significantly lower for the pilot study group than the national average (P<0.01). In comparison with the Department of Health survey the study population had significantly higher mean carbohydrate and protein intakes and significantly lower mean fat intakes as a percentage of energy intake (p<0.01).

As there were no comparable data for the younger age group the energy and micronutrient intakes of the 5-6 year old children were compared with the estimated average requirement (EAR) from the dietary reference values (DRVs) published by the Department of Health (see Table 3.6) (Department of Health, 1991). The mean energy intake was close to the EAR, however reported energy intakes were high in comparison with the 10 to 11 year olds participating in the study. The younger age group children reported consuming a diet in line with the recommendations in terms of percentage energy from fat, carbohydrate and protein.

Table 3-7 A comparison of the micronutrient intakes of children completing the food diaries with data from estimated average requirements[1] and a national survey[2]

	EAR[1]	Age 5-6 yrs (mean±sd)	DoH study[2] (mean±sd)	Age 10-11 yrs (mean±sd)	p[3]
Number		19	1723	19	
Calcium (mg)	350	910 (286.0)	810 (236.5)	695.2 (185.9)	0.17
Iron (mg)	4.7	8.5 (1.9)	9.2 (2.1)	7.6 (1.8)	<0.01
Vitamin A (mg)	300	514.9 (262.5)	440 (554.6)	378.1 (311.5)	<0.01
Vitamin C (mg)	20	145.8 (146.8)	41.55 (35.2)	99.2 (78.2)	<0.01
Thiamin (ug)	0.3	1.5 (0.5)	1.07 (0.3)	1.7 (2.3)	<0.01

[1] EAR estimated average requirement for 5 to 6 year olds (Department of Health, 1991)
[2] Intakes of 10 to 11 year old children taking part in the Diets of British Schoolchildren survey (Department of Health, 1989)
[3] The p value given is the significance of the difference between the 10 to 11 year olds in the pilot study and the 10 to 11 year olds taking part in the Diets of British Schoolchildren survey (Department of Health, 1989)

Table 3.7 shows a comparison of the micronutrient intakes reported by the 10-11 year old children completing the food diaries with data from the Department of Health survey 'The Diets of British school children' (Department of Health, 1989). 10-11 year old children had lower mean intakes of calcium, iron and vitamin A and higher intakes of vitamin C and thiamin than those reported in the Department of Health survey (Department of Health, 1989). All of these differences were significant (p<0.01) apart from calcium (p=0.17). The 5-6 year old children's mean intakes exceeded the EAR (Department of Health, 1991) for all micronutrients.

3.12.1 Validation of lunch items reported in the food diary against photographs

In School 2 lunches were photographed on one of the recording days. This enabled a comparison of the lunch recorded in the food diaries with that actually eaten. The number of items missing, that is eaten but not recorded, and the number of phantom foods, that is recorded but not eaten, are shown in Table 3.8.

Table 3.8 Foods reported compared with foods consumed

Age in years	Total No. of foods in photographed lunches	Missing foods (Eaten but not recorded)	Phantom foods (Recorded but not eaten)
5-6	41	7	4
10-11	44	9	4
10-11 *	39	4	1

*Note: One of the 10-11 year olds lost his diary and brought in an account of his meal on paper. The meal he recorded having eaten and the actual meal from the photograph were completely different and this child accounted for 5 of the missing and of 3 the phantom foods. The results for this age group are also presented with this child excluded.

The data in Table 3.8 show that of the 24 children for whom a photograph of their lunch was available, those in year 1(aged 5-6 years) correctly reported 83% of all foods consumed. Four foods that were reported as being consumed as part of the 9 lunches photographed did not appear in the photo and were classified as 'phantom foods'. Excluding the subject who lost his diary and reported consuming a school meal completely different from that photographed, year 6 children (aged 10-11 years) correctly reported 90% of all foods consumed. Only one 'phantom food' was recorded for the remaining 8 lunches.

3.12.2 Validation of estimated weights of food using the food photographs against average portion served

In addition to taking photographs of meals at school 2 average portions of school dinners as served by the catering staff were obtained by weighing 2 or more samples of each food served. This allowed a comparison of the portion selected by the child using the food atlas with the amount served. Unfortunately uptake of school dinners amongst the study group was low. Only two children interviewed had a school dinner, results for these children are shown in Table 3.9. Both children were in year 1 (aged 5-6 years).

Table 3.9 Reported weights compared with average weight served

Food	Average weight served in g	Weight (g) chosen by subject No. 2	Weight (g) chosen by subject No. 6
Sausage	46 each	43 each	43 each
Yorkshire pudding	24	78	39
Roast potato	28	262	99
Milk/juice	110	160	100

It appears that the weight of sausages may be reasonably well estimated using the food photographs, but for roast potatoes the two children grossly overestimated the amount using the food photographs. With data from only two children available no conclusions can be drawn.

3.12.3 Relative validation of the food record

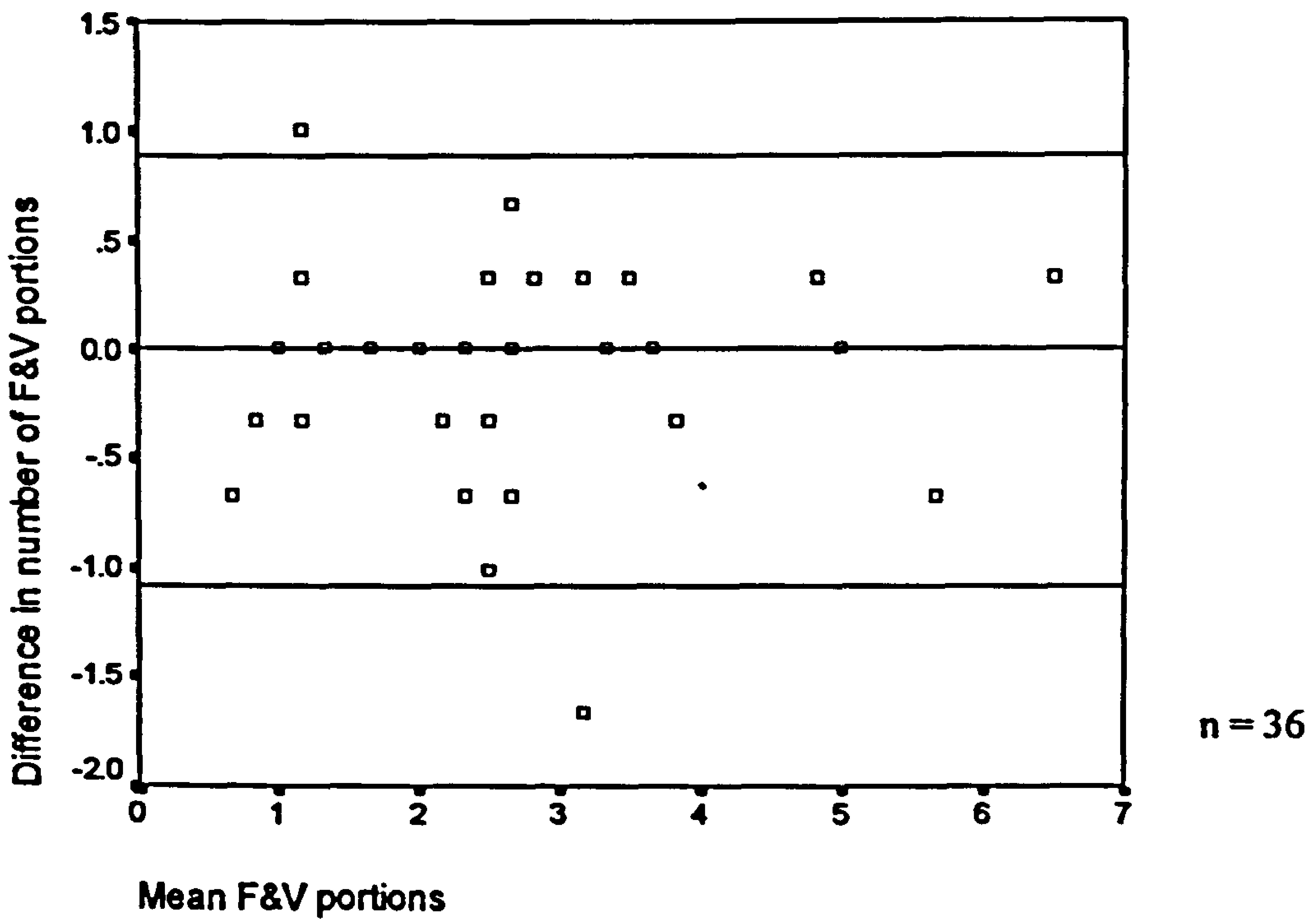
The food record was designed to collect data on the number of portions of fruit and vegetables consumed only. No attempt was made to measure the weight of the portions consumed. Table 3.10 shows the mean portions of fruit, vegetables and fruit and vegetables recorded using the food record and the food diary, the difference between the two methods and the significance of the difference.

Table 3.10 Relative validation of the food record method against the food diary

No. of subjects n= 36	Portions record (mean±sd)	Portions diary (mean±sd)	Difference (mean±sd)	Sig. (p)
Fruit	1.6 (0.95)	1.7 (0.97)	-0.083 (0.0823)	0.318
Vegetable	0.96 (0.80)	0.97 (0.77)	-0.0093 (0.057)	0.875
Fruit and Vegetable	2.6 (1.3)	2.7 (1.3)	-0.093 (0.081)	0.263

Bland Altman plots were produced to assess the level of agreement in measuring portions of fruit and vegetables between the two methods at the individual level (Figure 3.1). The difference between the two methods was calculated by subtracting the number of portions of fruit and vegetables recorded in the food diary from that recorded in the food record. A positive value therefore represents an overestimation of fruit and vegetable intake using the food record compared with the food diary.

Figure 3.1 Plot of the difference in the number of fruit and vegetable portions recorded in the diary and the food record against the mean of those two measures



The limits of agreement, which are defined as the mean of the difference between fruit and vegetable portions by the two methods plus and minus 2 standard deviations were +0.88 to −1.07. This means at the individual level the food record could differ by +0.88 to −1.07 portions from the result of the food diary. For 78% of the individuals in the study population the number of fruit and vegetable portions recorded using the food record was within 0.5 of a portion of the number measured using the food diary.

At the group level the food record method was found to give results not significantly different from those achieved by the food diary. The group mean intakes of fruit and vegetables recorded were similar whether the chosen method of assessment was the food record or the food diary.

3.13 Feedback from subjects and their parents

3.13.1 Problems with the food record

Of the children returning completed food records, 61% also returned a completed feedback form (Appendix 8). It was not possible to separate the feedback by year. Problems with the food record were encountered by 23% of the subjects returning the feedback form. This was low compared with 37% of subjects encountering problems with the food diary. This may be because the food diary is a more demanding instrument in terms of the subject time and commitment required. Despite this, when asked to specify particular problems encountered, the majority of comments received concerned problems with the food record. The major theme of comments made related to the use of the four food groups. Parents and children were keen to record all foods eaten rather than just those in the four groups. Feedback to the question of how the food record might be improved included

> *'Perhaps to include dairy products and cereal' and 'More sections i.e. meat, cheese and snacks.'*

In particular parents were concerned that they did not appear to be providing a sufficient diet for their child if only the food groups included in the food record were reported. One parent commented:

> *'If I only put on what was in the pictures it would look like he was being starved!'*

Another said :

> *'My child got upset because although he ate well over the 3 days very little was recorded on your sheet. Perhaps if they could write down their whole meal and you use the relevant information for your research.'*

Some parents avoided this concern by recording all items eaten. Composite meals which included vegetable ingredients also posed problems. One parent commented:

'I made soup and spaghetti boulagnaise – both had vegetables added in the cooking. I was unsure whether to break down the meal to incorporate this under the vegetable category or not.'

There was some confusion over which foods to record in each category. This would not be eliminated by including all food groups but it may be that some of the confusion arose from the subject's, or parents, desire to record everything eaten.

A couple of parents also commented that 3 days was too short a time to gain a good picture of their child's intake perhaps indicating willingness to complete the record over a longer period of time.

3.13.2 Problems with the food diary

Few specific comments were made concerning the food diary, except that the younger children were unable to fill the diary in independently. Comments were received such as *'Mam had no problems!!'*, however it was always the intention to include parental help in the completion of the method. During the pilot study some children did not bring their diary to school until it had been completed. During the interviews many of the younger children struggled to remember foods consumed more than a day previously. In the main, the older children were able to remember foods eaten even three days before.

3.14 Modifications made to the food record

The food record was redeveloped with clearer instructions, strongly emphasising that it was only foods within the four groups that were to be recorded and that the record was not intended to measure total diet. The food picture dictionary was extended to include more in the bread and biscuits categories (Appendix 11). In addition, examples of foods to include and foods not to include as fruit and vegetables were given based on foods which were incorrectly recorded during the pilot study (Appendix 12). An example page of a completed day was included (Appendix 13). The instructions for completion of the food record were altered to reassure parents that it is normal for the pages to look relatively empty due to recording food intake of four types of food only.

3.15 Modifications made to the food diary

The food diary remained the same apart from the inclusion of an example page of a completed day (Appendix 14). As with the food record, an explanation of which meals to include in morning, afternoon and evening was included. It was decided that the younger children (5-6 year olds) would be interviewed on a daily basis throughout the 3-day recording period whereas the older children (10-11 year olds) would be seen once at the end of the recording period. The instruction to parents' letter was altered so that the importance of bringing the diary to school each day for the interview was stated in bold text and underlined. It was hoped that this, along with reminder slips, would alleviate the problem of parents keeping the diary at home until the end of the recording period.

3.16 Discussion of the pilot study

3.16.1 Accuracy of the methods

- **Relative validity of the food record**

The rationale for comparing the accuracy of the food record relative to the food diary was that the food diary is a more established method. The weighed food diary is considered by some a 'Gold standard' (Black *et al.*, 1991) and has been used by many to assess the relative validity of other methods (Willett *et al.*, 1985; O'Donnell *et al.*, 1991; Bingham *et al.*, 1994). The estimated weight food diary used in this study was conducted for only 3 days and did not require the subjects to weigh the foods they had eaten. Subjects did however tend to record more information about individual foods in the food diary than in the food record. For example, an entry of *'juice'* in the food record may have been written in the food diary as *'Robinsons blackcurrant squash, no added sugar'*. In addition the interview allowed clarification of information recorded in the food diary whereas there was no such opportunity with the food record.

A comparison of each child's food diary with their concurrent food record identified areas where problems had occurred frequently. Fruit juice was the most common problem. Children recorded fruit squashes as fruit juice despite clear instructions not to. This error was identified during the interview for the food diary but went undetected for the food record, for which no interview was conducted. Fruit juice, along with baked beans were also frequently missed from the food record despite their inclusion in the fruit and vegetable dictionary. Another problem was the inclusion of fruit flavoured items such as yoghurts and sweets in the fruit section. For example one year 6 pupil according to the food record ate raspberries, strawberries and blueberries. On examination of the food diary this turned out to be the fruit part of a Muller fruit corner yoghurt. The food record clearly required a more in-depth explanation of the foods that should and should not be included as fruit and vegetables to avoid such confusion.

Despite the problems encountered with the food record the mean difference in fruit and vegetable portions at the group level, between the food record and the food diary was less than 0.1 portion per day. From the Bland Altman plot (Figure 3.1) the difference between the food record and the food diary for fruit and vegetable portions at the individual level was less than 0.5 portions for 78% of the children. Although the differences between the food diary and the food record were small in terms of portions of fruit and vegetables recorded, from previous studies it is known that the changes in intake as the result of a fruit and vegetable intervention are likely to be of this magnitude (Nicklas *et al.*, 1998; Reynolds *et al.*, 1999; Baranowski *et al.*, 2000; Reynolds *et al.*, 2000). Therefore as the record would not be able to detect a change of less than a portion it would be an unsuitable method to assess the impact of an intervention on an individual's fruit and vegetable intake. However as the agreement was good at the group level and the impact of the intervention was to be monitored at the group level the food record was kept as the method for measuring change in fruit and vegetable intake.

3.16.2 Validity of the food diary

- **Comparison with national dietary survey data**

The reported intakes of nutrients from the food diary were compared with a nationally representative sample of the same age. Although more subjects and parents indicated they had encountered problems completing the food diary, compared with the food record, fewer specific problems were reported and completion rates were very high. Attendance at the interviews was good in general with the only problem being younger children forgetting to bring their diary to school each day.

Intakes of both macronutrients and micronutrients were compared with national averages for 10-11 year olds (Department of Health, 1989). Data collection for the Department of Health study took place in 1983, 16 years prior to this study. The data collection method used then was a 7-day weighed diary, the limitations of which are discussed in the previous chapter (Section 2.3.1 and Section 2.4.3).

The differences in intake seen between the pilot study data and the national sample are in line with changes in intake which have been reported over the past 50 years (See Section 2.2.1). These include a decrease in energy intake and percentage energy derived from fat, and a reduction in intakes of calcium and iron (Widdowson, 1947; Gregory and Lowe, 2000). Time and financial constraints did not allow for a more extensive validation of the method such as DLW or measuring plasma ferritin, vitamin C or carotenoid concentrations (Section 2.4.2).

Unfortunately at the time of the pilot study no such data were available for comparison with the dietary intakes recorded for the 5-6 year old age group as no national scale survey had been conducted with children of this age. The nutrient intakes reported for the 5-6 year old children were compared with the EAR for this age group (Department of Health, 1991a). These children were found to be exceeding the estimated average requirement for all nutrients examined (Department of Health, 1991a).

- **Validation of reported intakes against observed intakes**

The agreement between the lunch items (both from school dinner and packed lunches) reported in the food diary and those actually consumed was good. Year 1 and year 6 children reported correctly 83% and 90% of foods respectively. Comparison with a number of similar studies reveals this level of accuracy is relatively high. Lytle *et al.* (1993) used a similar method (24hr recall prompted by a record of observed food intake) with children aged 7-8 years old and found 78% agreement between reported and observed meal and snack items. The reason the accuracy was slightly lower than that found in the present pilot study may be because the authors examined the accuracy of reports of both meals and snacks. Meals are generally reported with greater accuracy than snacks (Gibson, 1990). However in comparison with other studies which validated reports of a single meal accuracy of children in the present study is still high. In 1973 Emmons and Hayes used a 24hr recall method with children of 6 years and found that they reported accurately only 60.5% of the food items consumed at school dinner (Emmons and Hayes, 1973). For 10 year old children accuracy increased to 80.6% but, still lower than the accuracy achieved by the 5 to 6 year olds in the present study. Moreover Domel *et al.* (1997) found that interviewing children within 90 minutes of their school dinner only 40% of children aged 8-9 years were completely accurate in reporting the items they consumed for school dinner.

The accuracy with which children from both age groups reported the items of food they consumed at school dinner was highly satisfactory compared with previous studies. (Baranowski *et al.*, 1986) describe an 82.9% agreement between observer and child reports of food items consumed as 'acceptably high'.

- **Validity of the food photographs for estimating food portion sizes**

Unfortunately due to the low uptake of school dinners no conclusions can be drawn concerning the validity of the food photograph method for estimating the weight of food consumed by primary school children. Although the estimates made by the two participants who consumed school dinner during the study period were far from accurate, further observations would be required before conclusions could be drawn. Food photographs (Nelson *et al.*, 1997) were kept as the means for assessing portion size at interview as time and financial constraints meant portion sizes had to be estimated rather than weighed. In the absence of evidence that any other portion size assessment aid would be preferable, this method was employed with plans to carry out further validation of the method during the intervention study. Ideally further validation of the food photographs for use with primary school children would have been carried out prior to the use of the method during the main study. Unfortunately the time allocated to development and pilot testing of these tools was insufficient for such studies to be undertaken. The project began in April 1999, pilot testing of the tools was undertaken during June and July of 1999 and dietary assessments for the main study began at the end of August 1999.

Chapter 4 Fruit and vegetable intervention study

4.1 Introduction

A fruit and vegetable intervention using a whole school approach was carried out in primary schools in the Dundee area throughout one academic year. The intervention was implemented by a team working at the University of Dundee and included changes to the school dinner menu, a fruit and vegetable tuck shop and curriculum aspects (Anderson *et al.* (In press). The evaluation of the intervention was conducted by a team from the University of Newcastle. The impact of the intervention on the children's diets was assessed using the two methods of measuring dietary intake in primary school children, which were developed and tested during the pilot study (Chapter 3). A team from the Psychology department of the University of Dundee assessed the impact of the intervention on children's attitudes towards fruit and vegetables and their preferences for various foods including different fruits and vegetables (Higgins *et al.*, 2001). This work was funded initially by the Ministry of Agriculture Fisheries and Food and subsequently by the Food Standards Agency.

4.2 Aims

- To measure the impact of a fruit and vegetable intervention using a whole school approach, using the food record to assess change in intake of fruit and vegetables throughout the 9 months of the study from T0 (before the intervention commenced) to T1 (midway through the intervention) and T2 (the end of the intervention). The primary outcome was change in number of fruit and vegetable portions from T0 to T1 and T0 to T2.
- To use the food diary with a sub-sample of children to ensure that there are no detrimental effects of the intervention on any aspect of the children's diet. Food diary measurements were to be made at T0 and T2 only, due to the greater demand of these methods, both on the subjects and on research resources. The secondary outcome was change in nutrient intake from T0 to T2.

4.3 Methods

4.3.1 The Schools

Four primary schools in the Dundee area were recruited to take part in the fruit and vegetable intervention study. The schools were selected to be in areas of social deprivation. Ethical approval for the study was obtained from the Tayside Committee on Medical Research Ethics (ref 263/98). The schools were matched for depcat scores (a measure of deprivation based on post-code (Carstairs and Morris, 1991)) and free school meal entitlement prior to randomisation, to give two pairs of schools. One of the schools in each pair were randomised to receive the intervention (St. Joseph's and Newfields) and one of each pair acted as controls (Our Lady's and Rosebank).

4.3.2 The subjects

All children attending the four schools were invited to take part in the study. Children in primary years 2 (5-6 year olds) and 7 (10-11 year olds)[1] were particularly targeted for assessment as these were the year groups in which the curriculum aspects of the intervention were implemented. Letters inviting children to take part in the study and seeking parental consent were sent to the parents of all children attending the four schools. The response rate was lower than had been expected and because of this a second letter was sent out to parents (Appendix 15).

All children for whom completed consent forms were received were asked to complete three food records. The protocol stated that a sub-sample of 50 children in years 2 and 7 in each of the intervention and control groups would be asked to complete food diaries. This gave a target of 200 diaries. All consenting children in primary years 2 and 7 were asked to complete two 3-day food diaries in addition to the food records. In practice since the schools taking part in the study were small and the overall response rate was low children were recruited from adjacent year groups to make up the numbers completing both methods. Letters were sent to the parents of all children completing food diaries to ask for consent to weigh and measure their child at school.

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[1] Primary 2 is equivalent to the English Year 1, Primary 7 is equivalent to the English Year 6

At T0 the completion rate of the food record was low (Table 4.3) to increase the study sample additional children were recruited to keep food records at T1 and T2.

4.3.3 Distribution of food records and food diaries to children

Due to time restrictions and the complexity of working around lessons for the large number of children involved, it was not possible to give the children verbal instructions on completing the food diaries and the food records as had been done for the pilot study. Instead an envelope containing the food record and if appropriate the food diary along with a letter to the parent or guardian was distributed to all participating children. Written instructions were included on the covers of the food diary and food record and in the instruction letter to parents (Appendix 16). A contact number was given both in the letter and on the cover of the diary in case any of the children or their parents had any problems or queries concerning the food records or diaries.

4.4 Data collection

4.4.1 Timetable of collection

The intervention ran from mid September 1999 to June 2000. Data collection took place at three time-points throughout the 99/00 school year (Table 4.1). All data collection took place in school during school hours. Baseline (T0) measurements were made from two weeks prior to commencement of the intervention (week -2) to week 2 of the intervention, with measurements being made in the intervention schools in the first two weeks, before the intervention began. Mid-point (T1) measurements were made in week 18 and week 19 of the intervention. Final (T2) measurements were made week 34 to week 37 of the intervention. Food records were collected at all three time-points whereas food diaries were collected at T0 and T2 only.

4.4.2 Food record

The 3-day food record was to be completed at each time-point. Records were distributed to participating children on day -1 at each time point and collected from school on day 4. To ensure all completed records were returned reminders were sent home with children who did not return their record within two days of completion.

4.4.3 Food diary

The 3-day food diary with interview using the food photographs (Nelson *et al.*, 1997) was used according to the methods described in section 3.7.1. The younger children were interviewed on a daily basis to ensure that the required information was as 'fresh in their minds' as possible. The older children were seen once at the end of the three-day recording period to review the full 3-day's intake. All children were sent reminders the day prior to any interview they were required to attend requesting that they bring their food diary into school with them the following day.

The data collection period for the food diary was limited to one week in each school at T0 and one week at T2. In order to ensure all interviews were completed in the time available three interviewers were recruited to conduct the interviews with the children. The interviewers attended a one week training course with the author prior to commencing the study (Appendix 17). All interviews were conducted in the same room as and supervised by the author

Table 4.1 Timetable for the Fruit and Vegetable study

Activity	Week	-2	-1	0	1	2	3	↔	18	19	20	↔	33	34	35	36	37
Food diaries distributed																	
Food diary interviews conducted																	
Food records distributed and collected																	

Week 1 was week commencing 6th September

Week 37 was week commencing 29th May

Key

St Josephs (Intervention school) Yellow

Newfields (Intervention school) Blue

Our Lady's (Control school) Red

Rosebank (Control school) Green

4.4.4 Data for validation of the food diary with food photographs method

School canteens were visited on each day that pupils completed food diaries. Weights of standard portions served of each food on offer were obtained by weighing two or more samples of each food served. This enabled a comparison of the actual weights of foods served with the weight of food the child selected using the food photographs.

4.5 Data Handling

4.5.1 Coding and data entry

All data collected from each child were coded for entry into a Microsoft ACCESS database that had been specially developed during the pilot study. The same procedures used during the pilot study for assigning food codes and entering data into the database were followed. These procedures are described in sections 3.8.1 and 3.8.2. In addition any fruit or vegetable consumed was flagged in the food diary in order to facilitate comparison of fruit and vegetable consumption recorded in the food record with that recorded in the food diary.

- **Additional foods**

A number of foods were consumed by the children for which no food codes were available. The nutrient composition was obtained from packaging or contact with the manufacturer and wherever possible a close match in terms of nutrient composition was found from the available food codes. However for some foods no such match was available. For these foods new codes were assigned and information on their nutrient content was obtained either from manufacturers or by food dissection and entered into the food tables.

4.5.2 Data checks

Only diaries or records that had been completed at each required time-point for the full three-day period were included in the analysis.

The data were checked for any data entry errors manually by comparing the information in the diary or record with that entered onto the entry form within the Microsoft ACCESS database. In addition the data were checked for coding errors as described in section 3.8.3.

4.6 Data analysis

The primary outcome was change in number of fruit and vegetable portions from T0 to T1 and T0 to T2. The secondary outcome was change in intake of various key nutrients (likely to increase with increased fruit and vegetable consumption) between T0 and T2. The significance of the difference between the change in intake in the intervention group and that in the control group was tested. Difference in change rather than difference in intake at T0, T1 and T2 between the intervention and control groups was used to allow for any differences in total dietary intake or fruit and vegetable intake that may have been present at baseline.

4.6.1 Fruit and vegetables included in the analysis

Fruit and vegetables were included in the analysis according to the recommendations of the National Heart Forum (NHF, 1997). Fruit and vegetables were included whether they were raw, cooked, frozen or canned. Potatoes and other starchy staples were excluded due to their high starch content. Fruit juice was included but counted only once per day as recommended (NHF, 1997). Baked beans were included as suggested by the National Heart Forum however it was decided to count only one portion per day. Dried fruits were included but nuts were excluded on the recommendation of the Principal Investigator for the fruit and vegetable intervention study. Composite foods were included provided the dish contained a high proportion of fruit and vegetables therefore vegetable lasagne was included in the analysis whereas fruit yoghurts were not. Composite foods such as vegetable lasagne were included but counted for only one portion.

4.6.2 Food record

Food records collected from children who completed all 3-days at all 3 time-points were included in the analysis. The average daily frequency of consumption of fruit, vegetables, and fruit and vegetables together was calculated for each individual at each time-point. The change in these frequencies between the different time-points was then calculated by subtracting the earlier frequency from the latter. Fruit T0 to T1 was calculated by subtracting frequency of fruit intake at T0 from that at T1, therefore a positive value represented an increase in intake.

Multiple regression was performed on the difference in change in intake between each time-point. This examined whether any change in intake between the time-points was significantly different for the control and intervention groups. Age and sex were included, as covariates, to ensure any differences seen were not due to differences in the population demographics or a different degree of change by different age and sex groups.

4.6.3 Relative validation of the food record method

The relative validity of the food record as a method for measuring intake of fruit and vegetables in a primary school population was assessed. Relative validation of the food record against the food diary was conducted as the food diary is a more established method of dietary assessment. The number of portions of fruit, vegetables, and fruit and vegetables together as measured by the food record were compared against the frequencies obtained using the food diaries. To test whether the difference between fruit and vegetable intakes measured by the food diary and the food record were significantly different from zero a one sample t-test was used. Bland Altman plots were used to examine the agreement between the two methods at an individual level.

4.6.4 Food diary

Food diaries were included in the analysis if the child had completed the diaries at both time-points for the full 3-day period and had been interviewed covering all 6 days. Mean daily food and nutrient intakes were calculated from the 3-day totals and change from T0 to T2 was calculated for each variable by subtracting intake at T0 from that at T2.

- **Total dietary intakes**

Paired t-tests were performed to analyse the significance of any changes in macro-nutrient and micronutrient intakes between T0 and T2 for both the intervention and control groups. An independent t-test was performed on the dietary intakes of energy, percentage energy as fat, carbohydrate and protein and total dietary intake of starch, sucrose, calcium, vitamin C and iron to assess whether there were significant differences in intake between the control and intervention groups at either T0 or T2. A multiple regression was performed including age and sex to assess whether any significant differences in change in intake could be accounted for by differences in the subjects in each group.

- **Fruit and vegetable intakes**

In addition to calculating total dietary intakes from the food diaries they were also used to examine fruit, vegetable and fruit and vegetable intake. This allowed the detection of a change in fruit or vegetable intakes that may have occurred due to e.g. an increase in portion size rather than an increase in the frequency of consumption.

Mean daily intakes in terms of frequency and weight of fruit, vegetables, and fruit and vegetables were calculated. A paired t-test was performed to test the significance of changes in intake of fruit and vegetables between T0 and T2 for the intervention and control groups separately. An independent t-test was performed on change in consumption of fruit, vegetables and fruit and vegetables both in terms of frequency of consumption and weight. This assessed whether differences in change in intake between the control and intervention groups were significant.

4.6.5 Validation of the food diary with food photograph method

- **Reported energy intake as measured by the food diaries**

The proportion of subjects suspected of under- or overreporting their energy intake collected using the food diaries was compared with that from the National Diet and Nutrition Survey (NDNS) of Young People (Gregory and Lowe, 2000) for the relevant age groups These data were published in 2000 and therefore had not been available at the time of the pilot study. The NDNS employed a 7-day weighed inventory along with interviews involving both the child and parent.

For children completing food diaries body weight (kg) was measured. This enabled prediction of the child's basal metabolic rate (BMR) from standard equations using the child's body weight (Schofield *et al.* 1985).

Children 3-10 years

Males	BMR (MJ/day) = 0.095 wt + 2.110
Females	BMR (MJ/day) = 0.085 wt + 2.033

Children 10-18 years

Males	BMR (MJ/day) = 0.074 wt + 2.754
Females	BMR (MJ/day) = 0.056 wt + 2.898

As there is some overlap of the age categories children for children 10 years old and above the calculations for children aged 10 to 18 years were used. Cut-off points based on multiples of BMR were used to identify suspected under- and overreporters. To allow for comparison with the number of children suspected of under- and overreporting in the NDNS survey which used a 7 day weighed diary the calculations and exclusion criteria used were those used in the NDNS of Young People (Gregory and Lowe, 2000). These cut-offs were proposed for use with children and adolescents by Torun *et al.* (1996):

Males and females aged 1-5 years	1.28-1.79 x BMR
Males aged 6-18 years	1.39-2.24 x BMR
Females aged 6-18 years	1.30-2.10 x BMR

- **A comparison of the children's estimates of portion size using the food photographs with the average portion served at school dinner**

The weights selected for the portion size of food served, using the food photograph atlas, for foods consumed at school dinner were compared against the known weights of foods served. The method of Bland Altman (Bland and Altman, 1986) was used to measure the agreement between children's estimates of portion size and the actual weight of the portion. The difference between the child's estimate of the weight of the food and the actual weight of food is plotted against the mean of these two weights. Ideally the difference between the two weights would be zero, that is there would be no difference between the child's estimate of the food's weight and the average weight of the portion of food served. By examining the distribution of the points around zero it is possible to assess the accuracy of the children's estimates of portion size and to detect bias towards under- or overreporting.

Percent errors were also calculated using the formula:

(estimated weight – actual weight) X 100 / actual weight.

This enabled the calculation of the mean percentage error for different age groups and different foods, and the number of children estimating to within a given percentage of the actual weight of a given food.

4.7 Results

4.7.1 The subjects of the study

The final overall response rate was low with only 48% of all children invited to take part, returning completed consent forms. Children were asked to consent to both the food record and the food diary. The low response rate may be due to the fact that data collection took place at three time-points over a full academic year and therefore required a long term commitment. The control schools had a markedly lower response rate than the intervention schools (Table 4.2).

Table 4.2 Number of children consenting to taking part in the study in intervention and control schools

School	No. pupils	No. consents	% response rate
Intervention	511	267	52%
Control	464	201	43%
Total	975	468	48%

Table 4.3 Number of children completing the assessments at each time-point

	Completion of food diaries* Number (% of consents)			Completion of food records Number (% of consents)			
School	T0	T2	T0 and T2	T0	T1 †	T2 †	All
Intervention	94 (70%)	67 (50%)	63 (47%)	169 (63%)	161 (60%)	106 (39%)	71 (27%)
Control	83 (69%)	69 (57%)	65 (54%)	102 (51%)	132 (61%)	99 (46%)	49 (24%)
Total	177 (69%)	136 (53%)	128 (50%)	271 (56%)	293 (60%)	205 (42%)	120 (26%)

† Further subjects were recruited to complete food records at T1 and T2 prior to T1 data collection.* Food diaries were not collected at T1

Table 4.3 shows the completion rates of the food diary and food records. Completion rates for the food diary (50%) were higher than for the food record (25%). Children completing the food records were required to complete them at three time-points throughout the academic year. Completion rates at T0 (56%) and T1 (60%) were relatively high but there appeared to be a fatigue effect with poor completion rates at T2. Only 26% of the subjects completed food records at all three time-points.

Table 4.4 Demographics of the children completing food diaries at both time-points

		No.	Age (mean±sd)	Post Codes (%)[1] Depcat score 1-3	4-6	Numbers Eating School Meals	(%)[2]
Intervention Schools	Male	28	8.4 (2.28)	21%	79%	17	(61%)
	Female	36	8.5 (2.19)	22%	78%	21	(58%)
	Total	64	8.4 (2.21)	22%	78%	38	(59%)
Control Schools	Male	31	8.1 (2.11)	13%	87%	20	(65%)
	Female	34	9.2 (2.23)	12%	88%	23	(68%)
	Total	65	8.6 (2.23)	12%	88%	43	(66%)

1. Depcat scores range from 1 being the most affluent households to 7 being those most deprived.
2. Number of children attending school meals includes children who attended school meals at-least once during either data collection period.

Table 4.4 shows the demographics of those children completing the food diaries at both time-points. The mean ages of the children were similar in the intervention and control schools. The schools were matched on depcat scores (Depcat scores categorise deprivation category (Carstairs and Morris, 1991) 4-6 most deprived, 1-3 least deprived) and free school meal entitlement data gathered from the schools themselves (data not shown). Free school meal entitlement was very high in comparison with 14% of children taking part in the NDNS survey (Gregory and Lowe, 2000). Three of the four schools involved were similar in terms of these characteristics. The remaining school was in a less deprived area. This was due to restrictions on the schools available for recruitment due to a large dental survey which was going on in the schools in the area concurrently. This school was assigned to the intervention group and accounts for the lower percentage of high depcat scores in the intervention group. The number of children attending school meals was important since this indicates the number and proportion of children for whom estimated weight of foods served could be compared with the average serving weight.

Table 4.5 Anthropometric measurements of children taking part in the fruit and vegetable intervention study[1]

		No.	Weight (Kg) (mean±sd)	Height (m) (mean±sd)	BMI (mean±sd)	No (%) overweight/ obese
Intervention Schools	5-7 year olds	17	25.6 (4.3)	1.29 (4.3)	15.2 (1.6)	
	9-11 year olds	28	43.2 (13.6)	1.51 (0.1)	18.8 (4.2)	
	Total	45	36.6 (13.9)	1.43 (0.1)	17.4 (3.8)	
Control Schools	5-7 year olds	25	25.8 (4.4)	1.23 (0.1)	17.0 (2.0)	
	9-11 year olds	22	43.3 (12.2)	1.47 (0.1)	19.7 (4.2)	
	Total	47	34.0 (12.5)	1.34 (0.1)	18.3 (3.4)	

[1] Not all children consented to height and weight measurements

The intervention and control groups were fairly well matched in terms of body weight and height. Mean BMI was slightly higher in the control group (18.3) compared with the intervention group for both age groups (17.4). The difference in BMI was significant for the younger age group ($P<0.01$) but not overall (Table 4.5).

4.7.2 Fruit and vegetable intakes by food record

Table 4.6 shows the changes in the frequency of fruit and vegetable consumption from T0 to T1 and T2 as measured by the food records. From T0 to T1 there was a significant difference in the change in intake of fruit (p=0.023), and intake of fruit and vegetables (p=0.011), between the intervention and control groups. Intakes of fruit and vegetables increased in the intervention group and decreased in the control group. At the end of the intervention period (36 weeks) this effect was no longer significant.

Table 4.6 Mean (SD) daily frequency of consumption of fruit and vegetables at T0, T1 and T2, as measured by 3-day food records in intervention (n=71) and control groups (n=49)

Variable[1]	T0		T1		T2		Sig[2] of Intervention effect	Sig[2] of Intervention effect
	Mean	SD	Mean	SD	Mean	SD	T0 to T1	T0 to T2
Fruit frequency								
Intervention	1.4	0.81	1.6	0.83	1.6	0.89	0.023	0.820
Control	1.1	0.90	0.9	0.85	1.3	1.11		
Veg frequency								
Intervention	1.2	0.97	1.2	1.0	1.1	0.98	0.124	0.494
Control	1.2	1.11	0.9	0.8	1.0	0.90		
F&V frequency								
Intervention	2.5	1.5	2.7	1.5	2.7	1.5	0.011	0.515
Control	2.3	1.6	1.8	1.4	2.3	1.7		

1. Frequency adjusted to include only one portion of fruit juice and one portion of baked beans per day.
2. The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups

No significant differences in change in intake from T0 to T2 were seen between the intervention and control groups. Therefore from the food records it appears there were some short term beneficial effects of the intervention on fruit intake and fruit and vegetable intake.

Tables 4.7 and 4.8 examine whether there were differential effects of the intervention with age. There was a slight increase in the frequency of fruit and vegetable intakes of the 5 to 7 year olds from T0 to T1 (p=0.06) however intakes had returned to baseline levels by T2 (Table 4.7). For the 8 to 10 year olds there was a slight increase in the frequency of fruit and vegetable intake from T0 to T2, this was due entirely to an increase in fruit intakes (Table 4.8). There were no significant changes in intake between T0 and T2 for either age group.

Table 4.7 Mean (SD) daily frequency of consumption of fruit and vegetables at T0, T1 and T2, as measured by 3-day food records in intervention (n=37) and control groups (n=17) – 5 to 7 year olds

Variable[1]	T0		T1		T2		Sig[2] of Intervention effect	Sig[3] of Intervention effect
	Mean	SD	Mean	SD	Mean	SD	T0 to T1	T0 to T2
Fruit frequency								
Intervention	1.4	0.81	1.6	0.83	1.5	0.76	0.254	0.359
Control	1.2	0.87	1.1	0.98	1.5	1.47		
Veg frequency								
Intervention	1.2	0.87	1.3	1.07	1.0	0.87	0.143	0.739
Control	1.4	1.21	1.1	0.88	1.3	1.01		
F&V frequency								
Intervention	2.5	1.37	2.9	1.6	2.5	1.35	0.060	0.398
Control	2.7	1.84	2.2	1.64	2.9	2.03		

[1].Frequency adjusted to include only one portion of fruit juice and one portion of baked beans per day.
[2].The value shown is the significance of the difference in change in intake from T0 to T1 between the intervention and control groups
[3].The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups

Table 4.8 Mean (SD) daily frequency of consumption of fruit and vegetables at T0, T1 and T2, as measured by 3-day food records in intervention (n=34) and control groups (n=32) – 8 to 11 year olds

Variable[1]	T0		T1		T2		Sig[2] of Intervention effect	Sig[3] of Intervention effect
	Mean	SD	Mean	SD	Mean	SD	T0 to T1	T0 to T2
Fruit frequency								
Intervention	1.4	0.82	1.6	0.84	1.60	1.03	0.068	0.456
Control	1.1	0.93	0.9	0.79	1.1	0.87		
Veg frequency								
Intervention	1.2	1.08	1.0	0.80	1.2	1.09	0.638	0.303
Control	1.1	1.07	0.8	0.77	0.8	0.79		
F&V frequency								
Intervention	2.6	1.62	2.5	1.31	2.8	1.72	0.135	0.218
Control	2.2	1.53	1.6	1.31	1.9	1.38		

1. Frequency adjusted to include only one portion of fruit juice and one portion of baked beans per day.
2. The value shown is the significance of the difference in change in intake from T0 to T1 between the intervention and control groups
3. The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups

The changes made to the food record following the pilot study appear not to have fully addressed the problems with this method (paragraph 3.13.1). Poor completion rates of the food record coupled with the advantage of having weights of fruits and vegetables consumed meant the food diary was also used to assess fruit and vegetable intake.

4.7.3 Fruit and vegetable intakes by food diary

Table 4.9 Mean (SD) daily frequency of consumption of fruit and vegetables as measured by 3-day food diaries in intervention (n=64) and control groups (n=65)

Variable[1]	T0		T2		Difference in intake		Intervention[2] effect
	Mean	SD	Mean	SD	Mean	SD	p
Fruit frequency							
Intervention	1.3	0.91	1.7	1.09	0.4	1.15	0.188
Control	0.9	0.89	1.0	1.01	0.1	0.86	
Vegetable frequency							
Intervention	1.2	0.95	1.1	1.01	-0.1	0.98	0.991
Control	1.2	0.89	1.1	0.79	-0.1	1.01	
F&V frequency							
Intervention	2.6	1.50	2.8	1.70	0.3	1.58	0.827
Control	2.0	1.37	2.0	1.35	0.0	1.06	

[1] Frequency adjusted to include only one portion of fruit juice and one portion of baked beans per day.
[2] The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups

Frequency of intake of fruit increased by 0.4 compared with 0.1 in the control group (Table 4.9). There was a slight decrease in the frequency of vegetable consumption in both the intervention and the control groups. For total fruit and vegetable intake frequency increased slightly (0.3) in the intervention group and remained stable in the control group. None of the changes in frequency of intake seen in the intervention group were significantly different from those in the control group.

The intervention had a greater impact on the frequency of fruit and vegetable intakes of the older children compared with the younger children. This was due to an increase in fruit intake (Table 4.10 and Table 4.11). For the older children the increase in the frequency of fruit intake was greater than the control group and this reached marginal significance (p= 0.067).

Table 4.10 Mean (SD) daily frequency of consumption of fruit and vegetables as measured by 3-day food diaries in intervention (n=33) and control groups (n=32) – 5 to 7 year olds

Variable[1]	T0		T2		Difference in intake		Intervention[2] effect
	Mean	SD	Mean	SD	Mean	SD	p
Fruit frequency							
Intervention	1.4	0.77	1.5	0.90	0.1	0.98	0.913
Control	1.0	0.91	1.1	1.26	0.1	0.77	
Vegetable frequency							
Intervention	0.9	0.59	0.9	0.88	0.0	0.81	0.891
Control	1.0	0.95	1.0	0.69	0.0	1.03	
F&V frequency							
Intervention	2.3	0.96	2.4	1.36	0.1	1.38	0.981
Control	2.0	1.50	2.1	1.51	0.1	1.08	

1. Frequency adjusted to include only one portion of fruit juice and one portion of baked beans per day.
2. The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups

Table 4.11 Mean (SD) daily frequency of consumption of fruit and vegetables as measured by 3-day food diaries in intervention (n=30) and control groups (n=33) – 8 to 11 year olds

Variable[1]	T0		T2		Difference in intake		Intervention[2] effect
	Mean	SD	Mean	SD	Mean	SD	p
Fruit frequency							
Intervention	1.3	1.05	1.9	1.24	0.64	1.27	0.067
Control	0.8	0.87	0.9	0.69	0.12	0.95	
Vegetable frequency							
Intervention	1.6	1.13	1.4	1.09	-0.2	1.14	0.889
Control	1.3	0.82	1.2	0.89	-0.2	1.01	
F&V frequency							
Intervention	2.9	1.90	3.3	1.91	0.4	1.77	0.199
Control	2.1	1.25	2.0	1.20	0.0	1.05	

[1]·Frequency adjusted to include only one portion of fruit juice and one portion of baked beans per day.
[2]·The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups

Table 4.12 Mean daily weight of fruit and vegetables consumed as measured by 3-day food diaries in intervention (n=64) and control groups (n=65)

Variable[1]	T0		T2		Intervention effect[2]
	Mean	SD	Mean	SD	p
Fruit weight					
Intervention	133	94.7	183	135.1	0.042
Control	100	94.6	107	114.7	
Vegetable weight					
Intervention	69	41.1	52	48.6	0.823
Control	70	58.1	55	42.3	
F&V weight					
Intervention	202	101.9	235	151.2	0.082
Control	170	109.6	163	120.8	

[1] The mean daily weights include conversions for fruit juice (dividing by a factor of 2.5) and for vegetable soups to include only vegetable content.
[2] The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups

Table 4.12 shows the change in weight of fruit and vegetables consumed from T0 to T2 as measured by the food diary. Considering the weight of fruit, vegetables and fruit and vegetables consumed fruit intake was found to increase significantly more in the intervention (+50g) group than the control group (+7g). Vegetable intake decreased in both intervention (-17g) and control groups (-15g) and, this between groups difference was not significant. Intake of fruit and vegetables together increased in the intervention group (33g) but this change was not significant from the change in the consumption by the children in the control group (-7g). This data is shown graphically in Figure 4.1.

The intervention had a much greater impact on the older children compared with the younger children in terms of the weight of fruit and vegetables consumed (Table 4.13 and Table 4.14). The 5 to 7 year olds intakes of fruit and vegetables decreased by 3g whilst the 8 to 11 year olds intakes increased by 73g. Again this was entirely due to an increase in the weight of fruit consumed (+86g). The increase in the weight of fruit (p=0.032), and fruit and vegetables (p=0.007) consumed was significantly greater for the older children in the intervention school compared with the controls (Table 4.14). For the 5 to 7 year olds there was actually a significant negative impact of the intervention on the weight of vegetables consumed (Table 4.13). Vegetable intakes decreased by 20g in the intervention school whereas intakes increased by 10g in the control schools, for this age group (p=0.046).

Table 4.13 Mean daily weight of fruit and vegetables consumed as measured by 3-day food diaries in intervention (n=33) and control groups (n=32) – 5 to 7 year olds

Variable[1]	T0		T2		Intervention effect[2]
	Mean	SD	Mean	SD	p
Fruit weight					
Intervention	136	85.6	154	93.6	0.506
Control	108	91.7	109	139.7	
Vegetable weight					
Intervention	62	43.5	42	38.5	0.046
Control	48	50.7	58	50.7	
F&V weight					
Intervention	198	97.8	195	105.1	0.646
Control	156	109.8	167	147.7	

1. The mean daily weights include conversions for fruit juice (dividing by a factor of 2.5) and for vegetable soups to include only vegetable content.
2. The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups

Table 4.14 Mean daily weight of fruit and vegetables consumed as measured by 3-day food diaries in intervention (n=30) and control groups (n=33) – 8 to 11 year olds

Variable[1]	T0		T2		Intervention effect[2]
	Mean	SD	Mean	SD	p
Fruit weight					
Intervention	129	105.1	215	165.2	0.032
Control	93	98.1	106	85.9	
Vegetable weight					
Intervention	77	37.5	64	56.1	0.128
Control	91	63.3	53	32.7	
F&V weight					
Intervention	205	107.8	278	181.5	0.007
Control	183	109.4	159	89.4	

1. The mean daily weights include conversions for fruit juice (dividing by a factor of 2.5) and for vegetable soups to include only vegetable content.
2. The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups

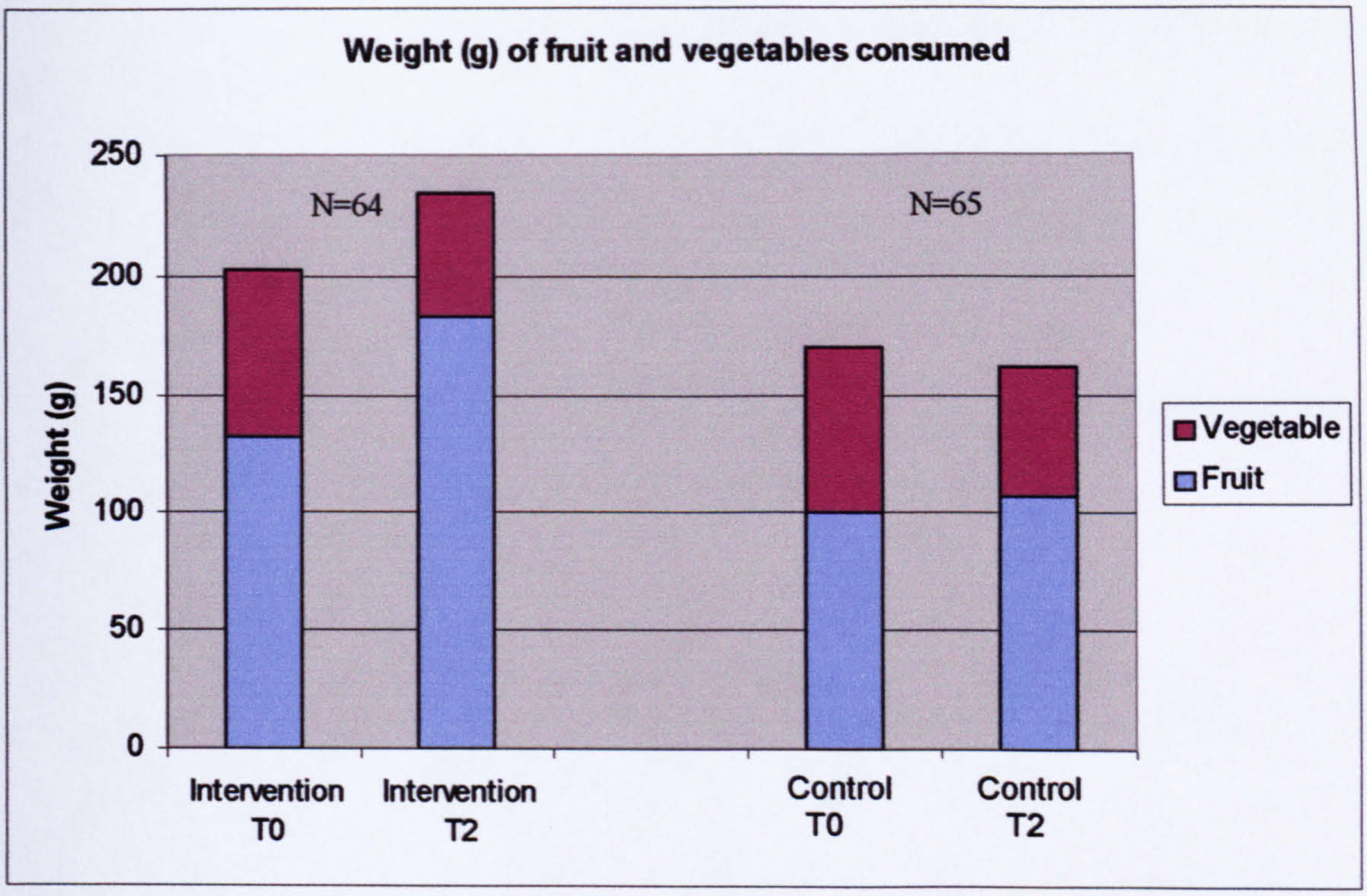


Figure 4.1 Fruit and vegetable intakes in the intervention and control schools

Figure 4.1 shows that the mean intakes of fruit and vegetables and in particular of fruit were higher in the intervention group than control at T0.

Table 4.15 Mean (sd) daily macronutrient intakes at T0 and T2 as measured by 3-day food diaries in intervention and control groups.

Variable	T0		T2		Intervention effect[1]
	Mean	SD	Mean	SD	p
Energy intake MJ					
Intervention	7.92	0.207	7.93	0.213	0.327
Control	8.28	0.257	7.92	0.236	
%Energy fat					
Intervention	35.4	0.65	34.9	0.56	0.929
Control	36.9	0.51	36.3	0.63	
%Energy carbohydrate					
Intervention	51.3	0.66	51.8	0.53	0.368
Control	49.8	0.60	51.2	0.62	
% Energy protein					
Intervention	13.1	0.29	13.1	0.28	0.097
Control	13.0	0.28	12.2	0.30	
Intake of Starch (g)					
Intervention	128	4.4	131	4.0	0.980
Control	131	4.5	134	4.3	
Intake of Sucrose (g)					
Intervention	55.1	17.5	54.6	19.4	0.578
Control	56.7	20.0	52.7	22.7	

[1]. The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups from a multiple regression model which included age and sex.

There were no significant differences in intake of macronutrients between the intervention and control groups either prior to the intervention or post-intervention (Table 4.15).

Table 4.16 Mean daily micronutrient intakes at T0 and T2 as measured by 3-day food diaries in intervention and control groups

Variable	T0		T2		Intervention effect[1]
	Mean	SD	Mean	SD	p
Intake of Calcium (mg)					
Intervention	900	36.6	807	31.2	0.792
Control	866	42.7	756	32.6	
Intake of Iron (mg)					
Intervention	9.5	0.43	9.2	0.47	0.644
Control	8.8	0.30	8.2	0.26	
Intake of Vitamin C (mg)					
Intervention	89.5	6.9	98.8	7.2	0.578
Control	76.4	6.5	79.4	6.8	
Intake of Beta Carotene (μg)					
Intervention	519	634.9	536	737.0	0.955
Control	529	1260.6	494	737.1	

[1]·The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups from a multiple regression model which included age and sex.

With the exception of baseline beta-carotene intakes, intakes of all micronutrients were higher in the intervention group compared with the control group. None of the differences in intake of micronutrients between the intervention and control groups were significant either prior to the intervention or post-intervention (Table 4.16).

4.8 Validation of the methods of dietary assessment

Validity is the extent to which an instrument measures what it was designed to measure. The relative validity of the food record to record fruit and vegetable intake was assessed by comparison with the concurrent 3-day estimated food diary. The nutrient intakes reported using the food diary method were compared with data from a nationally representative sample which reported dietary intake using a 7-day weighed inventory (Gregory and Lowe, 2000). The proportion of children suspected of over- or underreporting their energy intake was determined using energy intake cut-offs based on BMR (Torun *et al.,* 1996). The proportion of children providing reliable reports was compared with the proportion in the national survey (Gregory and Lowe, 2000) Finally the validity of the food photographs (Nelson *et al,*, 1997) to measure the portion size of foods consumed was assessed by comparison of children's estimates of food portions served at school dinner with known weights of foods served.

4.8.1 Comparison of frequency of fruit and vegetable intake by the food record and food diary methods.

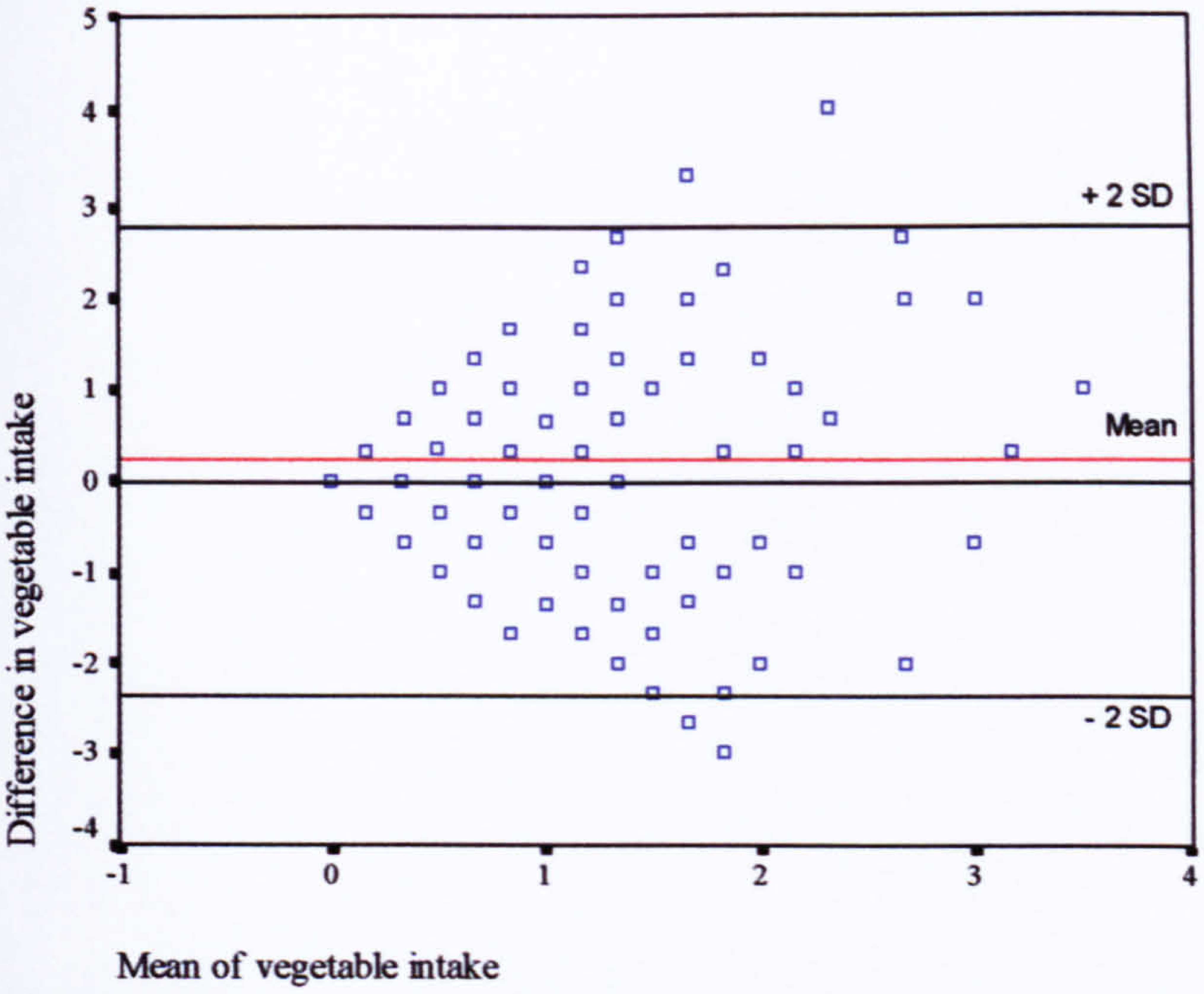
The relative validity of the food record was assessed by comparison of the frequency of fruit and vegetable intake recorded using the food record with that recorded using the food diary. 67 subjects completed both a food record and a food diary at T0 and T2. A one-sample t-test was performed to determine whether the difference between the frequency of intake of fruit and vegetable intakes as measured by the two methods was significantly different from zero. The difference between the two methods was calculated as the frequency of intake of fruit, vegetables or fruit and vegetables measured by the food diary minus the frequency measured using the food record. Therefore a positive value indicates the food diary measuring frequency to be higher than the food record and a negative value indicates the diary measuring frequency to be lower than the food record.

Table 4.17 Differences in the frequencies of fruit, vegetables and fruit and vegetables measured by the food diary and food records.

	No.	Difference in fruit frequency (mean±sd)	Sig (p)	Difference in vegetable frequency (mean±sd)	Sig (p)	Difference in fruit and vegetable frequency (mean±sd)	Sig (p)
5-7 year olds	68	-0.12 (1.441)	0.486	-0.02 (0.983)	0.867	-0.14 (1.987)	0.557
9-11 year olds	66	-0.10 (1.369)	0.571	0.47 (1.515)	0.013	0.38 (2.512)	0.225
All subjects	134	-0.11 (1.401)	0.368	0.22 (1.292)	0.047	0.11 (2.268)	0.561

At the group level the food record measured vegetable intake significantly higher than the food diary for 9-11 year olds and the group as a whole (p=0.047) but not for the 5-7 year olds. There was no significant difference in intake of fruit or fruit and vegetables for either age group or the group as a whole whether the food record or the food diary was used to assess intake (Table 4.17).

For measuring individual intakes the Bland Altman plots (Figures 4.2, 4.3 and 4.4) show that the limits of agreement for the food record are poor. In general the limits of agreement are narrower for the younger children compared with the older children. Considering fruit intake and vegetable intake separately the food records are within 3 portions per day of the food diary (Figure 4.2 and 4.3). Considering fruit and vegetables together the food record may provide an over- or underestimate of up to 5 portions per day for an individuals intake compared with the food diary (Figure 4.4).



n=134

Figure 4.2 Difference in vegetable intake against mean of vegetable intake by food record and food diary

The limits of agreement for the food diary in measuring individual vegetable intake were from +2.8 portions of vegetables to -2.4 portions.

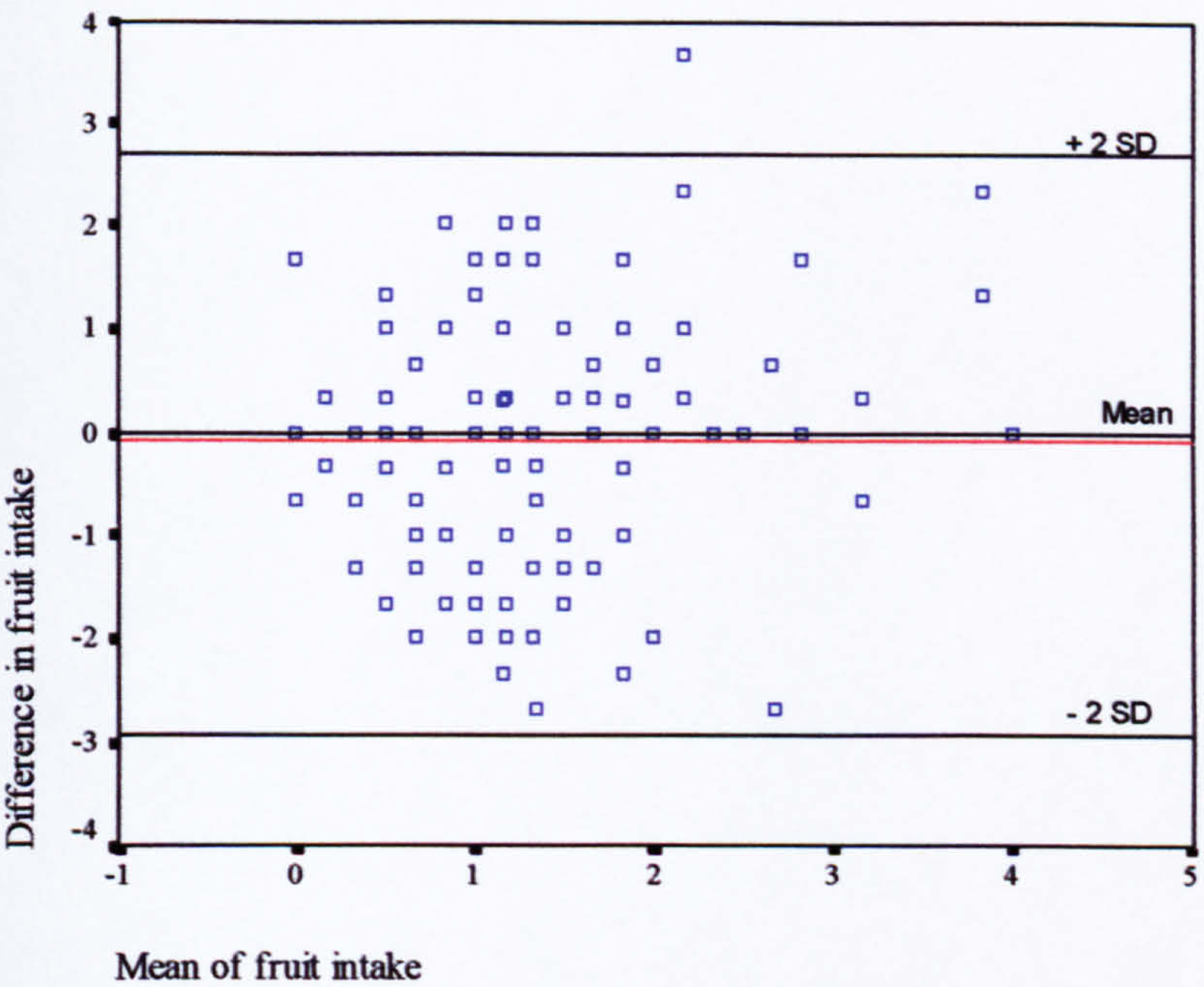


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Figure 4.3 Difference in fruit intake against mean of fruit intake by food record and food diary

The limits of agreement for the food diary in measuring individual fruit intake were from +2.7 portions of fruit to -2.9 portions.

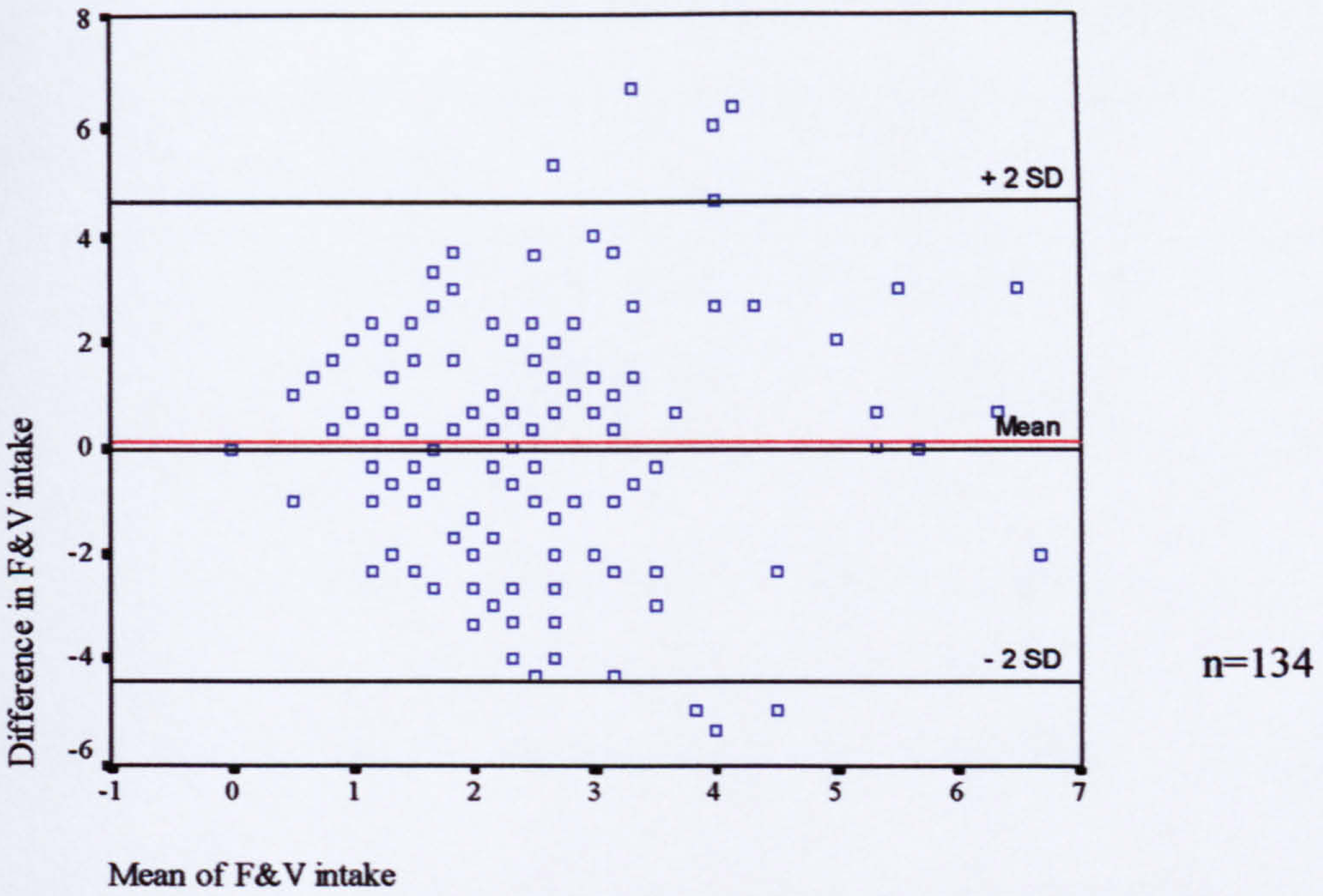


Figure 4.4 Difference in fruit and vegetable intake against mean of fruit and vegetable intake by food record and food diary

The limits of agreement for the food diary in measuring individual fruit and vegetable intake were from +4.6 portions of fruit to -4.4 portions.

4.8.2 Nature of recording errors

The recording errors seen with the food record were similar to those seen during the pilot study (Paragraph 3.3.1). Fruit juice and baked beans were commonly not recorded in the food record when according to the food diary they had been consumed. Where fruit juice was reported in the food record a number of entries were found to relate to fruit squashes or fizzy fruit flavoured drinks recorded in the food diary. In addition a number of children listed the vegetable ingredients of a meal, for example vegetable lasagne which would have counted as only one vegetable portion using our criteria (Paragraph 4.6.1) was recorded in the food record as mushrooms, tomatoes, peppers and carrots and would therefore have been counted as 4 portions.

4.8.3 Performance of the food diary with food photographs method

Table 4.18 A comparison of energy and macronutrient intakes from T0 food diaries with data from a national survey[1]

	NDNS 4-6 year olds	5-6 year olds (mean±sd)	p	NDNS 11-14 year olds (mean±sd)	10-11 year olds (mean±sd)	p
No.	355	53		475	54	
Energy MJ	6.1 (1.21)	8.0 (1.52)	<0.001	7.7 (1.70)	8.1 (2.04)	0.5
% Energy Fat	35.8 (4.16)	36.5 (4.15)	0.5	35.7 (4.64)	36.0 (5.01)	0.5
% Energy Carbohydrate	51.5 (4.67)	50.1 (4.79)	0.1	51.5 (4.92)	50.5 (5.37)	0.5
% Energy Protein	12.8 (1.87)	12.9 (2.11)	0.5	12.9 (2.19)	13.3 (2.40)	0.5

1. National Diet and Nutrition Survey (Gregory and Lowe, 2000)

Baseline reports of nutrient intakes from the food diaries were compared with data from a national survey (Gregory and Lowe, 2000). As can be seen from Table 4.18 intakes of energy and macronutrients measured by the food diary for both age groups were similar to the national averages (Gregory and Lowe, 2000). Data in the NDNS are presented for age groups 4 to 6 years, 7 to 10 years, 11 to 14 years and 15 to 16 years. As the age groups were not directly comparable with the ages of the children in this study the closest age group was used for comparison. For the younger age group percentage energy from fat was 36.5 compared with the average intake reported by a national sample of 35.8. Intakes of carbohydrate and protein as a percentage energy were 50.1 and 12.9 respectively, close to the national average for the age group (51.5 and 12.8). Compared with the national average for 4 to 6 year olds the mean energy intake of the 5 to 6 year old group was significantly higher (P<0.001).

No significant differences were seen between the energy intakes and dietary composition of the 10 to 11 year olds and the national average (11 to 14 year olds). Percentage energy from fat was 35.3 compared with the national average of 35.7. Intakes of carbohydrate and protein as a percentage energy were 51.2

and 13.3 respectively compared with national averages for the age group of 51.5 and 12.9. Energy intakes of the 10 to 11 year old group were similar to that of the 11 to 14 year old group in the national survey.

Table 4.19 Micronutrient intakes - comparison with national averages[1]

	NDNS 4-6 year olds	5-6 year olds (mean±sd)	P	NDNS 11-14 year olds	10-11 year olds (mean±sd)	P
No.	355	66		475	128	
Calcium (mg)	682 (239.7)	897 (289.3)	**<0.001**	720 (263.3)	842 (317.6)	**<0.01**
Iron (mg)	7.8 (2.29)	8.5 (1.96)	**<0.05**	9.8 (2.93)	9.5 (3.59)	0.5
Retinol (RE) (ug)	499 (236.6)	516 (238.2)	0.5	492 (488.3)	496 (323.5)	0.5
Vitamin C (mg)	66.1 (35.7)	91.9 (58.9)	**<0.001**	73.6 (48.8)	74.7 (46.1)	0.5

1. National Diet and Nutrition Survey (Gregory and Lowe, 2000)

- **Calcium intakes**

Mean intakes of calcium were higher than the national averages for both age groups. For the younger children mean calcium intake was 897mg compared with a national average for this age group of 682mg. For the older children the mean intake was 842mg whereas the national average was 720mg. These differences were highly significant (p<0.001, P<0.01 for younger and older children, respectively) (Table 4.19).

- **Iron intakes**

Table 4.19 shows the mean intakes of iron were similar to the national averages for both age groups. For the younger children mean intakes were slightly higher; 8.5mg compared with a national average of 7.8mg (p<0.05). Mean iron intakes of the older children were 9.5mg similar to the national average of 9.8mg.

- **Retinol equivalent intakes**

Mean retinol intakes were similar to the national averages for both age groups (Table 4.19). Mean daily intake for the younger children was 516µg compared with a national average of 499µg. For the older age group intakes were 496ug per day whereas the national mean was 492µg. Neither of these differences was statistically significant ($p<0.5$).

- **Vitamin C intakes**

From Table 4.19 it can be seen that mean intakes of vitamin C were higher than the national averages for both age groups. For the younger children mean vitamin C intake was 92mg compared with a national average for this age group of 66mg, this difference was highly significant ($p<0.001$). For the older children the mean intake was 74.4mg whereas the national average was 74 mg ($p<0.5$).

4.8.4 Exclusion of suspected under and overreporters

Three-day food diaries were collected at T0 and T2 from 129 children. For 91 (71%) of these a measure of body weight (kg) was also obtained. For children completing both food diary and body weight measurements cut-offs to identify children likely to have under- or over- reported (Torun *et al.*, 1996) were applied.

Table 4.20 Number of subjects suspected of under- and overreporting energy intakes

	5-7 year olds	9-11 year olds	Total
No. Children for whom body weight was available.	41	50	91
No. (%) underreporting	6 (15%)	33 (66%)	39 (43%)
According to Torun cut-offs[1]			
No. (%) overreporting	12 (29%)	7 (14%)	19 (21%)
According to Torun cut-offs[1]			
No. (%) reporting energy intakes within range	23 (56%)	10 (20%)	33 (36%)

[1]Torun *et al* (1996)

Using the same criteria for excluding under- and over- reporters as the NDNS (Section 4.6.5), around 15% of the younger children were classified as underreporters and 29% as overreporters (Table 4.20). This is slightly higher than the 11% and 15% of the younger age group identified as over- and under-reporters respectively in the NDNS report. The percentage of children classified as reliable reporters was 56% compared with 64% in the NDNS report.

For the older children the percentage reliable reporters was apparently lower with 14% overreporting, 66% underreporting and only 20% reporting energy intakes within the acceptable range. NDNS also report older children were less reliable with only 46% of the 11-14 year old age group classified as reliable reporters, 52.5% as underreporters and 1.5% as overreporters. The nutrient intake data were reanalysed to compare the data for all children for whom weight was available with data for children classified as 'valid reporters'. With the exception of baseline vitamin C intakes (where there was a difference of 11%) the nutrient intakes for the 'valid' reporters were within 5% of the values for all children who were weighed.

4.8.5 The validity of the food photographs for assessing portion size

The food atlas was used to obtain an estimate of portion size for each food reported in the food diary. This method was chosen as an alternative to asking children, or their parents, to weigh all foods the child consumed as this was seen as impractical when the child was spending a significant proportion of the day at school. In order to assess the accuracy with which children estimate food portion sizes using the food atlas (a tool designed for use with adults) children's estimates of the portion sizes of foods served at school dinner were compared with the weight of average servings. Percentage error was calculated for each estimate of food portion size using the formulae:

(estimated weight- actual weight) X 100 / actual weight

This gave a measure of the accuracy of the children's estimates of food portion size independent of the size of the portion served.

Table 4.21 Comparison of estimated portion size with average portion served at school dinner

Age years	Number of estimates	Difference in grams (mean±sd)	Sig (p)	Percentage error (mean±sd)
6	168	7.2 (43.5)	0.033	24.0 (76.3)
7	162	6.9 (43.2)	0.043	18.5 (61.1)
8	19	15.7 (46.5)	0.158	28.0 (77.6)
9	30	6.1 (49.8)	0.509	26.5 (101.2)
10	55	12.5 (41.3)	0.029	22.5 (62.3)
11	191	2.7 (43.2)	0.393	15.9 (65.0)
12	23	10.3 (50.3)	0.335	30.3 (61.8)

The mean weight of the food served was subtracted from the child's estimate of the food's portion size. A positive difference represents an overestimation of the size of the portion served and a negative value an underestimate.

From Table 4.21 it can be seen that even at the group level there were significant differences between the mean of the children's estimates and the actual weights of the foods. There was no clear trend for an improvement with age in the ability to estimate food portion size using food photographs. The mean percentage errors ranged from 15.9% for the 11 year old children, who also had the lowest mean difference between the children's estimates and the actual weight (2.7g), to 30.28% for the 12 year olds.

In order to compare the ability to estimate portion size of the older and younger children, the two age groups with the largest representations, 6 year olds and

11 year olds, were chosen for further analysis. Portion size estimates by children of 6 years old were within 10% of the actual weight of the food 21% of the time and within 30% of the actual weight of the food 45% of the time. For the older children 17% of portion size estimates were within 10% of the actual food weight and 44% of estimates were within 30% of the actual weight of the food.

The Bland Altman plots (Figures 4.5 and 4.6) show the difference between child estimates of portion size and the actual portion size served, against the mean of these two weights. Ideally all points would lie along the zero line indicating no difference between the estimates and the actual portion sizes. Both ages showed a tendency to overestimate small portions and to underestimate large portions. There was a slight trend towards overestimation in both age groups.

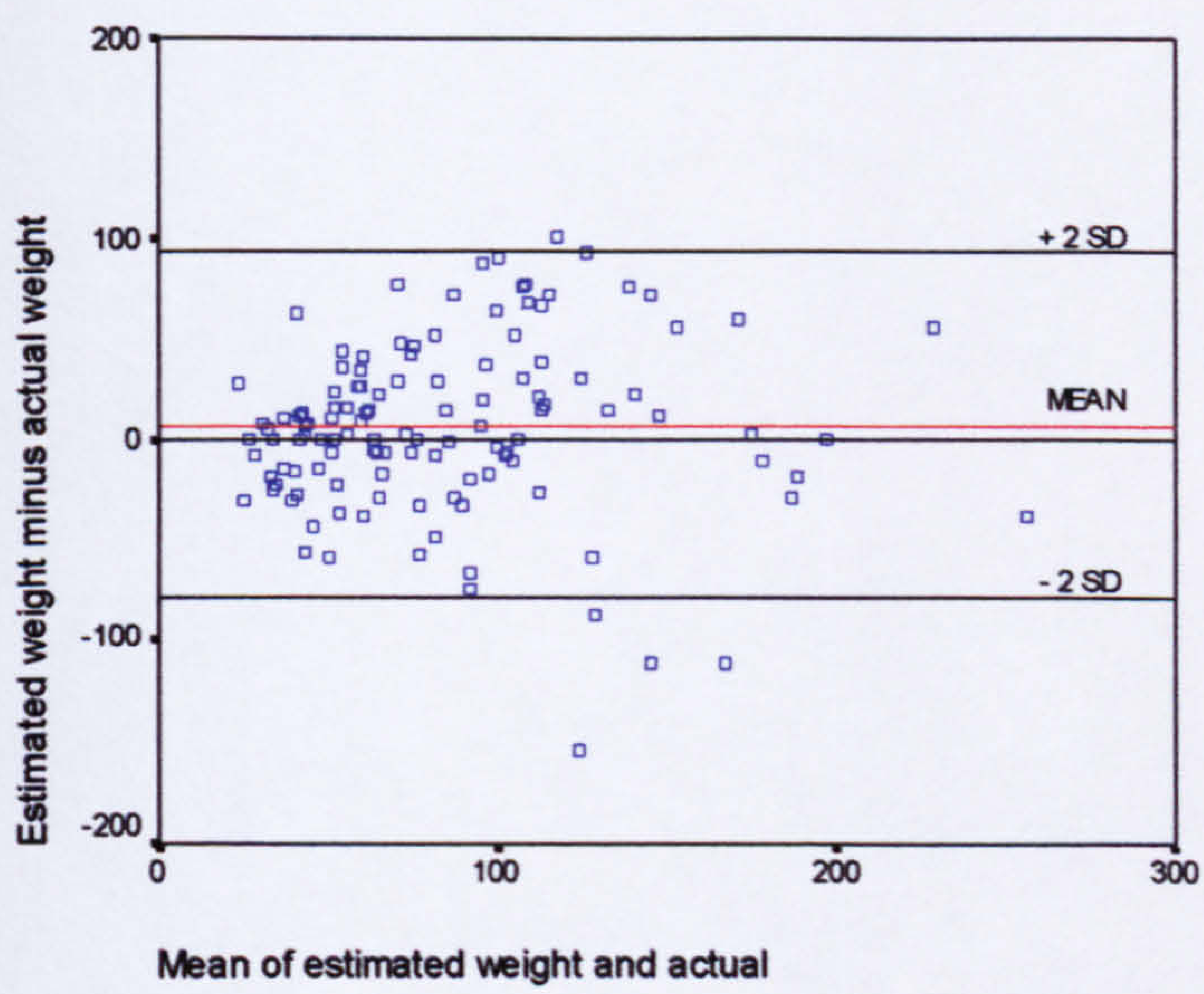


Figure 4.5 Bland Altman plot of portion size estimates by 6 year olds compared with the actual weight of the food (number of estimates 168)

The mean of the difference between the children's estimates of portion size and the mean weight of food served was 7.2g. The limits of agreement for the 6 year old children's estimates of portion size were +94g to -78g. These errors are huge given the average actual weight for the foods included in this analysis was 84.5g.

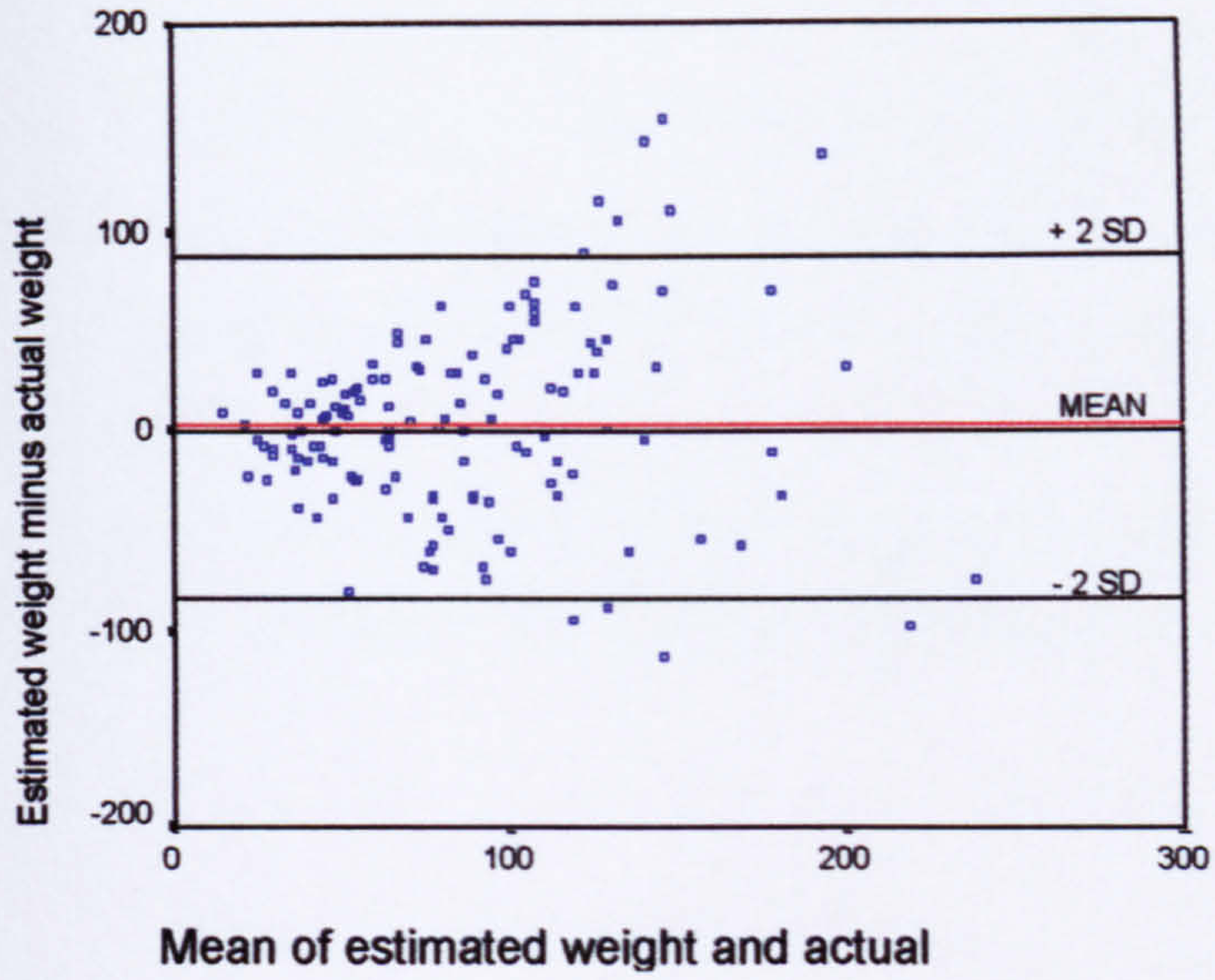


Figure 4.6 Bland Altman plot of portion size estimates by 11 year olds compared with the actual weight of the food (number of estimates 191)

The mean of the difference between the children's estimates of portion size and the mean weight of food served was 2.7g. The limits of agreement for the 11 year old children's estimates of portion size were +89g to -84g. Again these errors are large given the average actual weight for the foods included in this analysis was 81.3g.

The ability of the children to estimate portion sizes was also examined for different foods. Many of the foods were consumed by only small numbers of children however estimates for the most commonly consumed foods (those for which over 20 estimates were available) are reported below. Estimates made by children ages 4 to 12 years attending all four of the schools involved in the study are included in the Table 4.22. The portion size served for each food differed in each school. The variation in the range of portion sizes served for each food was large with weights served varying from 34g to 94g for chips, 92g to 158g for custard, 36g to 106g for cake and 70g to 122g for fish.

The majority of the foods were overestimated by the children with only three out of the top ten foods consumed at school dinner tending to be underestimated. Custard was the food most accurately estimated at the group level. On average children estimates differed by only 2.4% of the weight of custard and the mean estimate for custard was only 1.7g away from the actual weight of the portion served. A number of the mean estimates of food portion size were significantly different from the weight of the food served. Children's estimates of the weight of chips, fish, mashed potato and bread rolls were all highly significantly different from the actual weight of the food. The largest mean percentage error was seen for roast potatoes. Children on average overestimated by 67.1% of the weight of the roast potatoes. In terms of weight the mean difference was 19.1g, this reached borderline significance (p=0.06).

Table 4.22 Estimates of portion size made by children aged 4 to 12 - for different foods

Food	No. of estimations	Difference in grams (mean±sd)	Sig (p)	Percentage error (mean±sd)
Chips	90	11.4 (32.96)	**<0.001**	16.6 (45.16)
Custard	54	1.7 (36.86)	0.730	2.4 (35.95)
Cake	42	-1.8 (29.04)	0.688	10.6 (47.44)
Fish	31	32.8 (34.76)	**<0.001**	39.2 (41.09)
Boiled potato	30	13.0 (43.49)	0.113	16.3 (41.45)
Mashed potato	29	37.9 (44.74)	**<0.001**	55.4 (67.40)
Sweetcorn	24	8.7 (21.36)	0.058	24.3 (51.46)
Roast potato	23	19.1 (46.52)	0.061	67.1 (101.03)
Rolls	22	-12.1 (17.88)	**<0.01**	19.0 (32.09)
Salad	22	-1.2 (26.27)	0.839	5.1 (38.93)

4.9 Discussion

4.9.1 Subject participation

For both intervention and control schools the consent rate was disappointingly low. The control schools had a markedly lower response rate than the intervention schools. This may be due to increased teacher and staff enthusiasm for the project in the schools where the intervention was to take place. Especially in the primary school years the opinion of a teacher is likely to be very influential.

There was a reduction in subject enthusiasm for the study at each progressive time point evidenced by lower completion rates of the dietary assessment tools. This highlights the importance of maintaining the subject's interest and motivation to participate in a study. If only a select group of the study population complete the study the results are unlikely to be representative of the study population. The subjects in this study were asked to complete a minimum of three 3-day food records throughout one academic year. In addition a number of children were asked to complete two 3-day food diaries and attend 6 interviews to quantify the portion sizes for foods recorded in the diaries. Psychology tests (not reported here) to measure children's exposure to and preferences for different foods were conducted with the children completing the food diaries at all three time-points. The burden on the children, and parents, selected to complete all the methods was therefore considerable.

The lower completion rates of the food record may have been due to subjects who were asked to complete both tools completing only the more comprehensive food diary. Confusion over what to include and what not to include in the food record may have resulted in people abandoning completion of the food record.

4.9.2 Success of the fruit and vegetable intervention

Despite the limitations of the dietary assessment methods used to evaluate the impact of the intervention, the methods detected a small but significant increase in the mean daily intake of fruit in terms of the weight of fruit eaten. There was also a trend towards an increase (0.4 portions) in the mean daily frequency of fruit consumption but this did not reach statistical significance. The increase in fruit intake was offset by a decrease in the weight of vegetables eaten and a smaller decrease in the frequency of vegetable consumption. Overall there was a trend towards an increase in fruit and vegetable intake both in terms of frequency and amount consumed. However this difference was not significant.

The impact of this intervention was similar to results reported in studies conducted in US schools. School based fruit and vegetable intervention studies carried out in the USA have reported modest increases in intake ranging from 0.2 to 0.6 portions of fruit and vegetables per day. (Domel *et al.*, 1993; Nicklas *et al.*, 1998; Reynolds *et al.*, 1999; Baranowski *et al.*, 2000; Reynolds *et al.*, 2000). Domel (1993) had also found a fruit and vegetable intervention increased fruit intakes but had little effect on vegetable intakes and overall fruit and vegetable intake.

No significant changes in macronutrient or micronutrient intakes were found. It was hypothesised that the intervention would have a positive impact on intakes of certain micronutrients but no significant differences were detected. It is disappointing that the slight increase in fruit intakes seen in the intervention group did not appear to translate into improved intakes of for example vitamin C. There was a small increase in vitamin C intake in the intervention group but this was not significant. It may be that the changes in fruit and vegetable intake were too small to be reflected in altered micronutrient intakes. Alternatively the sample size, which was calculated to detect change in fruit and vegetable intake, may not have been large enough to detect a change in micronutrient intake. It is encouraging that there were no detrimental effects of the intervention on dietary intake and in particular that energy intake was not compromised.

The intervention appeared to have a much greater impact on the older primary school children compared with those children of 7 years or younger. It may be that this is a real difference and that the intervention delivered was more suited to the older age group. Alternatively the accuracy and precision of the methods of dietary assessment with the younger children may not have been sufficient to detected changes in intake in this age group. A final consideration is whether the older children were more aware of the fact that we were assessing the impact of the intervention on their intakes of fruit and vegetables and reported higher intakes than actually consumed or increased their intakes during the recording period in order to provide a 'socially desirable' report.

4.9.3 Relative validity of the food record

Despite the problems with the food record the differences in fruit and vegetable intake recorded in the intervention groups were in the same direction and of similar magnitude to those seen in previous fruit and vegetable intervention studies. The mean frequencies for fruit and fruit and vegetables recorded at T0 and T2 were similar to those recorded in the food diaries (at T0 and T2). There were however significant differences in the frequencies of vegetable intakes measured by the food record compared with the food diary, even at the group level. At the individual level the relative validity of the food record was poor. The Bland Altman plots show the food record resulted in a wide range of both over- and underestimation of fruit and vegetable intakes. The limits of agreement between the two methods were wide with the food record being out by up to five portions of fruit and vegetables compared with the food diary.

4.9.4 Problems associated with the food record.

The food record was intended to be a quick and simple method for assessing intake of fruit and vegetables in this age group. In practice however, it was found confusing by many of the children who participated in the extensive pilot study that was carried out. Many comments were received from both children and their parents that it was difficult to understand which foods should be included in the records, and a number suggested they would rather record all items from the diet. Comments were also received indicating that parents were concerned it would *"appear they were starving their child"* if only the foods covered by the record were included.

Following the pilot the food record was modified to include clearer instructions of what foods the children should include and foods not to include which had commonly been recorded in the pilot study. Efforts were made to reassure parents via a parental instruction letter that the record was not intended to record total diet and not to worry if the food record appeared relatively empty.

During the main study the completion rate for food records was less than that of the food diary 25% compared with 48%. This may have been for a number of reasons;

- The concept of the record seemed much harder for the young children to understand than the simple message of recording everything you eat as with the food diary.
- Psychology tests ran alongside the dietary assessment of the impact of the intervention. These showed that the young children had difficulty categorising foods as a fruit or vegetable and therefore using a method which required children to categorise foods may have been inappropriate.
- The presence of interviewers in the class on a daily basis during the recording period asking to see the children and their diaries probably boosted the return rate of the food diaries. Interviewers were only present in the classes completing food diaries and did not ask to see any children who were completing the food record only.
- Also children who were asked to complete food diaries and food records often completed the diary but not the record as they probably did not understand why they were being asked to record things twice (although parental letters explained the importance of completing both).

Mean fruit and vegetable frequencies from the food records were lower in those children who completed both methods compared with those who completed the record alone, suggesting that completing the food diary may also have reduced the accuracy with which the food record was completed (Appendix 18)

Other problems with completing the food records included fruit squashes, coke, iron bru and other drinks being recorded as "juice" in the food record. In Scotland the use of "juice" to describe all soft drinks is usual this has implications for future studies, care should be taken to ensure that the difference between fresh fruit juice and other soft drinks is emphasised. In addition the recording of individual ingredients of composite dishes such as vegetable lasagne, stews and fruit salads leads to discrepancies. Table 4.23 shows some of the common discrepancies which occurred between the food diary and the food records.

Table 4.23 Common discrepancies between the food record and the food diary

Food eaten	Entry in food record	No. portions	Entry in food diary	No. portions
Vegetable lasagne	Broccoli, Courgette, Carrots, Cauliflower	4	Vegetable lasagne	1
Fruit salad	Apple, Banana, Grapes	3	Fruit salad	1
Coke	Juice	1	Coke	0

Despite the problems encountered the frequencies of fruit, vegetables and fruit and vegetables reported using the food record were remarkably similar to those reported using the food diary.

4.9.5 Accuracy of the food diary

The food diary method is used extensively in dietary surveys (Department of Health, 1989; Gregory *et al*, 1990; Gregory and Lowe, 2000) The food diary may be weighed, estimated weight or use average portion sizes. Average portion sizes are available for adults (Crawley, 1993) but as yet there is no equivalent data available for children. The 7-day weighed food diary has been considered by a number of authors to be the best dietary assessment method available (Black *et al.*, 1991; Bingham *et al.*, 1995). It can give an accurate account of what the subject consumes during the recording period but there are a number of problems associated with the method (these have been described extensively in section 2.4.5). In brief these include recruiting an unrepresentative sample and low completion rates due to the high subject burden of the method and altering food intake to facilitate weighing. The foods consumed may be accurately reported but diet during the recording period may not be representative of habitual intake. Subjects have been shown to alter their diet to facilitate recording or to report a diet which is more socially acceptable (Livingstone *et al.*, 1990; Vuckovic *et al.*, 2000). The intensive nature of the method means the more motivated members of a population consent to taking part in the study and studies using weighed intakes have a bias towards enrolling educated participants (Rockett and Colditz, 1997). Therefore not only may the diet of the participants be unrepresentative of the population as a whole but the diet recorded may be unrepresentative of the participants' usual diets.

A food diary using food photographs to estimate the weights of foods consumed was selected as the method of assessing total dietary intake in this study. It was hoped this would reduce the burden of recording and so increase the number and range of individuals participating in the study and give a more accurate picture of the usual intake of the study population. In order to assess the accuracy of the method the mean dietary intakes of the study group were compared with national averages for the appropriate age groups.

Nutrient intakes reported at T0 were compared with the average reported intakes of a nationally representative sample (Gregory and Lowe, 2000), where data were collected using a 7-day weighed intake and an interview involving the parent and child. Ideally, due to the problems associated with the 7-day weighed intake (Section 2.4) biomarkers would be used to validate reported energy intakes against energy expenditure measured by DLW, reported protein intakes against urinary nitrogen excretion and reported vitamin intakes against plasma levels (Section 2.4.2). This was beyond the scope of the current study due to time and financial restrictions. Nutrient intakes in terms of percentage energy from fat, carbohydrate and protein were not significantly different from those reported in the national survey. Whilst the energy intakes of the older children were not significantly different from the national averages the younger children's intakes were substantially higher than the national average. This difference is unlikely to be explained by the slight age difference between the two groups. It is likely that the younger children overestimated their intakes using the 3-day food diary with photographs method as their mean energy intake was higher than the 10 to 11 year old children involved in the fruit and vegetable intervention study. This may be explained by the fact that the children overestimated portion size on average using the food photographs (Section 4.8.5). Some of the nutrient differences seen were in line with reported regional differences in food intakes. The higher iron intakes reported by the younger age group in this study may be explained by regional differences as NDNS report a higher proportion of Scottish children consuming many of the red meats and red meat dishes than other regions. Whereas the higher vitamin C intakes in the younger children and the higher calcium and retinol intakes in both age groups were contrary to what would be predicted by regional differences reported by NDNS (Gregory and Lowe, 2000). NDNS report a lower percentage of Scottish children consuming cooked carrots, green leafy vegetables and vegetables in general than any other region. Consumption of liver, liver products and dishes were also lower in the Scottish group.

It is difficult to determine whether differences in reported intakes are due to inaccuracies in the food diary and photographs method used in the fruit and vegetable intervention study or inaccuracies in the 7-day weighed intake. A more intensive validation study using bio-markers would be required in order to determine more accurately the validity of the food diary and photographs method.

4.9.6 Underreporting and overreporting

As subjects frequently underestimate their food intake a method of assessing the validity of the data collected should be an in-built part of any method of intake assessment. In the absence of more direct measures of validity of nutrient intakes, such as DLW and 24hr urine collections (Klein *et al.*, 1984), the most frequently used method of validation is to assess estimated energy requirements based on estimated basal metabolic rate (Goldberg, 1991).

The same criteria used in the NDNS survey (Torun *et al.*, 1996) were applied to identify children likely to have under- or over- reported their food intake (Gregory and Lowe, 2000). The numbers of children suspected of under- and over- reporting were higher than the corresponding numbers in the NDNS report but this is likely to reflect the different methods used. The longer the recording period the more likely the diet reported is habitual, therefore 3-day food diaries would be expected to be less valid than a 7-day food diary. Also the NDNS collected weighed food diaries whereas weights of foods consumed in the present study were estimated with the aid of food photographs. For both the NDNS and the current study the percentage of people classified as 'reliable reporters' is unacceptably low. In the current study the younger children were slightly more likely to overreport than underreport. Young children are likely to be under pressure to report that they have consumed all of the foods served to them. Older children on the other hand showed a clear bias toward underreporting. Underreporting is much more common in adults than overreporting and it is likely that the older children are beginning to be subjected to societal pressures which contribute to this phenomenon. The lower percentage reliable reporters may be due to the fact that the portion sizes of foods consumed were estimated using food photographs whereas the NDNS survey used 7-day weighed intakes. Errors in using the food photographs to estimate the weight of foods served may negate any benefit conferred by the reduced respondent burden.

4.9.7 Validity of estimates of portion size using food photographs

There were significant differences between the children's estimates of food portions sizes and the actual weight of the food even at the group level. There was no significant trend with age to suggest the children's ability to estimate food portions improves as they get older. The absence of an improved ability to assess portion size with age may be due to the different methods used with the younger and older children. The older children had a longer time between eating the food and making the portion size estimation and had to recall a full three days intake at one interview. The Bland Altman plots show that at the individual level the food photographs may result in the weight of food being under- or over- estimated by up to 90g (110% of the weight of food on average) compared with weighing the food. In this study however the foods were weighed by researchers, it is likely that greater errors in weighing would occur when the responsibility of weighing the foods was with the parent or child.

Unfortunately published data on the validity of food photographs with adults have not presented one-sample t-test data or Bland Altman plots. To allow direct comparison percentage errors were calculated. The validity of the food photograph method for use with young children was low compared with results reported by Lucas *et al.* (1995) who found 50% of adults (aged 20-60 years) were correct to within 10% of the actual weight of the food. However the study used only 3 food photographs and the portion of food presented was exactly the same as one of these 3 photographs. Nelson *et al.* (1994b) conducted a study with adults which had a more similar study design to this study. Adults were found to estimate portion size to within 30% of the actual weight 55% of the time. Around 45% of the children's portion size estimates using the food photographs were within 30% of the actual weight of the food therefore the validity of the food photograph method for use with primary school children may be approaching that of adults.

At the individual level at least it appears food photographs are a poor substitute for weighed intake. However due to the problems associated with weighed intake (Section 2.4) and the practicality of food photographs, photographs are commonly used as an aid to portion size assessment with children. At this point in time there is no clear evidence that food photographs are a valid tool for this age group. To address this fundamental issue a further study examining in more detail the ability of children to estimate portion sizes using the available portion size assessment aids, food photographs and food models was conducted (Chapter 5).

Chapter 5 Validity of methods for assessing food portion size with children

5.1 Introduction

Following the small scale validation of the utility of the food photograph atlas during the fruit and vegetable intervention study (section 4.8.5) the validity of this method for assessing portion size with young children was thrown into question. This method has been used quite widely as a visual aid to portion size assessment with children (Curtis, 2001; Anderson *et al.*, In press; Revill *et al.* 2001) and because of this, and the need for alternatives to the labour-intensive weighed inventory, a more extensive validation study was conducted. The study assessed the validity of two aids to portion size assessment commonly used with children.

- The first assessment aid was the MAFF food atlas (Nelson *et al.* , 1997), used in the pilot study (Appendix 4). It is a series of photographs depicting a range of foods with 8 portion sizes for each food (section 3.3.2) (Nelson *et al.*, 1994a). The food atlas has been validated for use with adults (Nelson *et al.*, 1996) but to date no work had examined whether this method is appropriate for use with children.
- The second portion size assessment aid was a set of food models. (Appendix 19) These included a series of shapes, cups, bowls and spoons which can be used to help describe the size of the food item consumed (Cameron and Van Staveran, 1988). These have been used in dietary surveys with children by Hackett *et al.* (1984) and Adamson *et al.* (1992).

5.2 Aim

The aim of this study was to assess the accuracy and precision with which children were able to estimate the size of portions of foods using two portion size assessment aids.

Accuracy is defined as deviating only slightly or within acceptable limits from a standard (YourDictionary.com, 2003).

Precision is defined as the number of significant digits to which a value has been reliably measured (YourDictionary.com, 2003). In terms of a method of estimating food portion size the method can be described as accurate if the mean value from a series of estimates is close to the actual weight of the food. The method can be considered precise if the variability of individual estimates around the mean is low.

5.3 Approaches

This study used three approaches to examine the validity of these two tools:

1. A 2-day weighed food diary where parents were asked to record and weigh all foods their child consumed, at home over 2 days. The children were then interviewed using each of the tools to obtain an estimate of the portion size of the foods they consumed for comparison with the weight recorded in the diary.
2. A school dinner diary where the child kept a record of all foods consumed at school dinner. Each child's school meal was photographed and an average serving for each food was weighed (two or more sample servings of each food consumed by children in the study were weighed). Each child was then interviewed using each of the tools to obtain an estimate of the portion size of the foods they had consumed for comparison with the average weight served.
3. A series of portion size interviews during which children were shown known amounts of foods and asked to estimate the amount using one of the tools for comparison with the actual weight of the food.

5.4 Recruitment of schools and children

5.4.1 Methods of recruitment

Ethical approval for the study was obtained from the Joint Ethics Committee, Newcastle and North Tyneside Health Authority (ref 2001/50). Four primary schools in the Newcastle area were recruited to take part in a study examining children's ability to estimate food portion sizes using food models and food photographs. The schools were Wharrier Street primary school (School A), Kingston Park primary school (School B), Welbeck primary school (School C) and St Charles' primary school (School D). Schools were contacted in the first instance by a letter to the head teacher detailing what would be involved in the study (Appendix 20). This was followed up by a telephone call one week later. Where the head teacher was interested in taking part in the study, a visit was arranged to discuss the study further and to arrange dates for the study to take place.

In School A children's perception and conceptualisation of food portion sizes was examined (Approach 3). In school B the utility of the food photographs and food models in portion size estimation was examined using a combination of 2-day food diaries and school dinner diaries (Approaches 1 and 2). The consent rate was very low in comparison to the response received from the same year groups to the pilot study conducted two years previously. The low response rate was deemed to be due to the number of different levels of participation in the study which meant that the letter and consent form were confusing (Appendix 21). It was decided to recruit two further schools and split the study intended to be carried out in school B into two parts. In school C children kept a diary of their school dinner on two occasions (Approach 2). In school D children and parents kept a 2-day weighed inventory of all food and drink consumed (Approach 1).

Table 5.1 shows the number of children attending each school and the percentage entitled to free school meals. The schools were selected to include children from a range of socio-economic backgrounds. Schools A and C were in relatively deprived areas with high percentage free school meal entitlement. Schools B and D were in relatively affluent areas, with low percentage free school meal entitlement.

Table 5.1 School roll and free school meal entitlement

School	School roll	% roll entitled to free school meal	% take up of free entitlement
School A	365	57	89
School B	428	8	83
School C	535	62	79
School D	205	2	79.3

Table 5.2 Summary of the study conducted in each school

School	Children recruited	Method	Approach
A	All children in years 1 and 6	Portion size perception and conceptualisation interviews	3
B	Children in years 1 and 6 who have school dinner	2-day school dinner diary OR 2-day weighed food diary	1 and 2
C	Children in years 1 and 6 who have school dinner	2-day school dinner diary	2
D	All children in years 1 and 6	2-day weighed food diary	1

Children were recruited from year groups 1 and 6 via a letter to their parents. In two of the schools (B and C) only children who ate school dinners were recruited. In the other two schools (A and D) recruitment letters were sent to the parents of all year 1 and year 6 children. A recruitment letter was designed for each school as the study design in each school was different (Appendix 21, 22, 23 and 24). The letters contained full details of what each study involved and a consent form for completion by the parent and child. All children returning completed consent forms were included in the study.

5.4.2 Results of recruitment

Table 5.3 shows the number of children targeted to take part in each of the three approaches, the number of children consenting to take part and the number of children completing each approach.

Consent rates ranged from 34% of 10 to 11 year olds consenting to keep a food diary and 34% of 5 to 6 year olds consenting to keep a school dinner diary to 57% of 10 to 11 year olds consenting to take part in the portion size perception interview.

Completion rates ranged from 91% completion of the portion size interview by the 10 to 11 year olds to 100% completion of the food diary by 10 to 11 year olds and 100% completion of the portion size interview by 5 to 6 year olds.

Table 5.3 Number of children consenting to taking part in the study.

Method	Age yrs	No. children targeted	No. consents (%) of children targeted	No. completing (%) of children consenting
Approach 1				
Food diary	5 to 6	36	21 (58%)	19 (90%)
	10 to 11	38	13 (34%)	13 (100%)
Approach 2				
School dinner diary	5 to 6	73	25 (34%)	24 (96%)
	10 to 11	77	40 (52%)	37 (93%)
Approach 3				
Portion size interview	5 to 6	47	21 (45%)	21 (100%)
	10 to 11	61	35 (57%)	32 (91%)

5.4.3 Discussion of recruitment

Consent rates for all methods were disappointingly low. The low response rates for Approach 1 (the food diary) were probably due to the amount of subject commitment that was required for completion of the 2-day weighed diary and also the need for parental involvement. In school B the children had the option of a food diary or a school dinner diary which led to confusion and a very low consent rate of 15%, this contributed to the low overall consent rate for Approaches 1 and 2. In school C where children completed school dinner diaries the consent rates were 49% for the year 1 children and 84% for the year 6 children. The difference between the two year groups may have been due to one of the year 1 classes having numerous supply teachers during the recruitment period. The other three class teachers were seen prior to distribution of the recruitment letters and were all very enthusiastic about the project. It is likely therefore that the study was not promoted in this one year 1 class in the same way as the other three classes. This highlights how significant the enthusiasm of the class teacher can be and indicates that on-going personal contact with the teacher is important in motivating the children initially and in focusing the children on the tasks during the study itself. The importance of the attitude of the teacher was also noted during the pilot study.

Although the consent rates were low, most of the children who consented to take part in the study completed it. Completion rates were very high with no method completed by less than 90% of consenting children. Children only failed to complete the interviews if they were absent from school.

Table 5.4 Demographics of children completing the study

Method	Age yrs	Male : Female	Mean age (years)
Approach 1	5 to 6	8 : 12	6.4
Food diary	10 to 11	3 : 10	11.3
Approach 2	5 to 6	17 : 7	6.5
School dinner diary	10 to 11	19 : 18	11.1
Approach 3	5 to 6	10 : 11	6.4
Portion size interview	10 to 11	15 : 20	11.4

Of the children completing the school dinner diary 59% were male. Of the children completing the food diary 67% were female. There were also more females than males completing the portion size interview (55%). Year 6 children made up 61% of the children completing the school dinner diary and 63% of the children attending the portion size interviews. Of the children completing food diaries 61% were in Year 1.

5.5 2-day weighed food diary (Approach 1)

5.5.1 Methods

An envelope containing the food diary along with a letter to the parent or guardian detailing what was required was distributed to all children consenting to complete a 2-day weighed food diary (Appendix 25). Parents were visited at home to distribute calibrated food scales, demonstrate the use of the scales and to explain how to complete the diary. Parents and children were instructed to record all food and drink consumed. Parents were asked to weigh all foods eaten at home using the scales provided and to weigh and record any leftovers. In addition the parents were asked to weigh any items which were prepared at home but eaten away, including packed lunches. An average weight of each food served at school dinner was collected by the researcher by weighing at least two servings of each food which was consumed by children taking part in the study.

Children were interviewed to obtain an estimate of portion size for each of the foods recorded in the diary. The children were interviewed the day following each of the two days of recording. One of the interviews was conducted using the food photograph atlas (Nelson *et al.*, 1997) and one using food models to quantify portions. The order of the tools used in the interviews was randomised in order to account for any potential learning effect which may have occurred. Children completing the 2-day food diary were weighed at school immediately prior to the second interview.

- **Data Handling**

Information on participating children such as name, date of birth, school class, gender and body weight were entered into an ACCESS database. The actual weight of the food served, as weighed by the parents was also entered along with the weight of any leftovers. Coding of foods was conducted as described in paragraph 3.8.1 and 3.8.2

- **Data analysis**

The methods of Bland Altman (Bland and Altman, 1986) and percentage errors were used to compare the children's estimates of portion size with the actual weight of food consumed as described in paragraph 4.8.5. Analysis of variance was used to examine whether there were any significant differences in ability to estimate portion size with portion size assessment tool by age, gender or test number. In addition a 2-sample t-test was used to test for possible differences with age between the performance of the two tools.

5.5.2 Results of the 2-day weighed food diary

As data collected using the 2-day weighed food diary included a wide variety of types and portion sizes of foods consumed the results presented are based on all foods consumed and all portion sizes.

- **Accuracy of portion size estimation by portion size assessment tool, gender and age**

Table 5.5 Error in children's estimates of portion size compared with actual weight from the food diary data

Factor		Number of observations	Percentage error	Mean ratio[1]	Standard error of the difference[2]	Sig p value
Tool	Models	32	17.9	1.18	0.077	0.093
	Photos	32	31.2	1.31		
Gender	Male	22	29.2	1.29	0.086	0.419
	Female	42	22.1	1.22		
Year	1	38	34.8	1.35	0.085	0.006
	6	26	9.7	1.10		
Overall mean			24.6	1.25		

1. Mean ratio is the mean ratio of the children's estimates of portion size to the actual weight.
2. The standard error of the difference given is the standard error of the difference between the mean ratio of the estimated weight to the actual weight using the food models and the food photographs.

Ratios of the child's estimate of the weight of the food to the actual weight varied from 1.10 to 1.35. No significant difference was seen between the children's ability to estimate portion size using the models and photographs although there was a non-significant trend for accuracy to be slightly greater with the models. There was no significant difference between boys' and girls' ability to estimate portion size. The older children were significantly more accurate in their estimate of portion size than younger pupils. Estimates made by the year 6 children were on average 109.7% of the actual weight of the food. Estimates made by the year 1 children were on average 134.8% of the actual weight of the food. Overall there was a trend for children to overestimate portion size. The mean percentage error for all children's estimates for all foods was 24.6% of the actual weight.

- **Age related differences in the accuracy of portion size estimation using each of the portion size assessment tools**

Table 5.6 Error in children's estimates of portion size compared with actual weight from the food diary data – Year 1 compared with Year 6 children

Age group	Tool	Mean ratio	SD	p^1	Mean diff between tools	95% CI	P^2
Year 1	Models	1.24	0.303	0.045	-0.22	-0.44, 0.00	0.180
	Photos	1.46	0.305				
Year 6	Models	1.09	0.415	0.184	-0.01	0.25, 0.23	
	Photos	1.10	0.193				

[1]The p value given is the significance of the difference between the tools
[2]The p value given is the significance of the difference between the difference in performance of the tools for each age group.

There was no significant difference between the difference in performance of the portion size assessment tools by age (Table 5.6). The older children were more accurate than the younger children in their estimates of portion size using both of the tools. The accuracy of estimates of portion size made by the older children were remarkably similar for both of the tools. The younger children were significantly more accurate in their estimates of portion size using the food models compared with the food photographs (p=0.045).

No evidence for an age-gender interaction was found.

- **Precision of portion size estimates - Bland Altman Plots to show the limits of agreement for the food models and food photographs in estimating portion size**

The Bland Altman plots (Figure 5.1 and 5.2) show the difference between child estimates of portion size and the actual portion size plotted against the mean of these two weights. Ideally all points would lie along the zero line indicating no difference between the estimates and the actual portion sizes. Children showed a tendency to overestimate portion size using both the food models and the food photographs. Children overestimated portion weight on average by 15g using the models and by 28g using the photographs. The mean actual weight of foods consumed was 99.4g with weights ranging from 2g to 500g. The limits of agreement (within 2 standard deviations of the mean) were unacceptably high using either method of portion size assessment. For the food models the limits of agreement were from 139g less than the actual weight of the food to 169g greater than the actual weight of the food. While the limits of agreement for the food photographs were from 176g less than the actual weight to 120g greater than the actual weight.

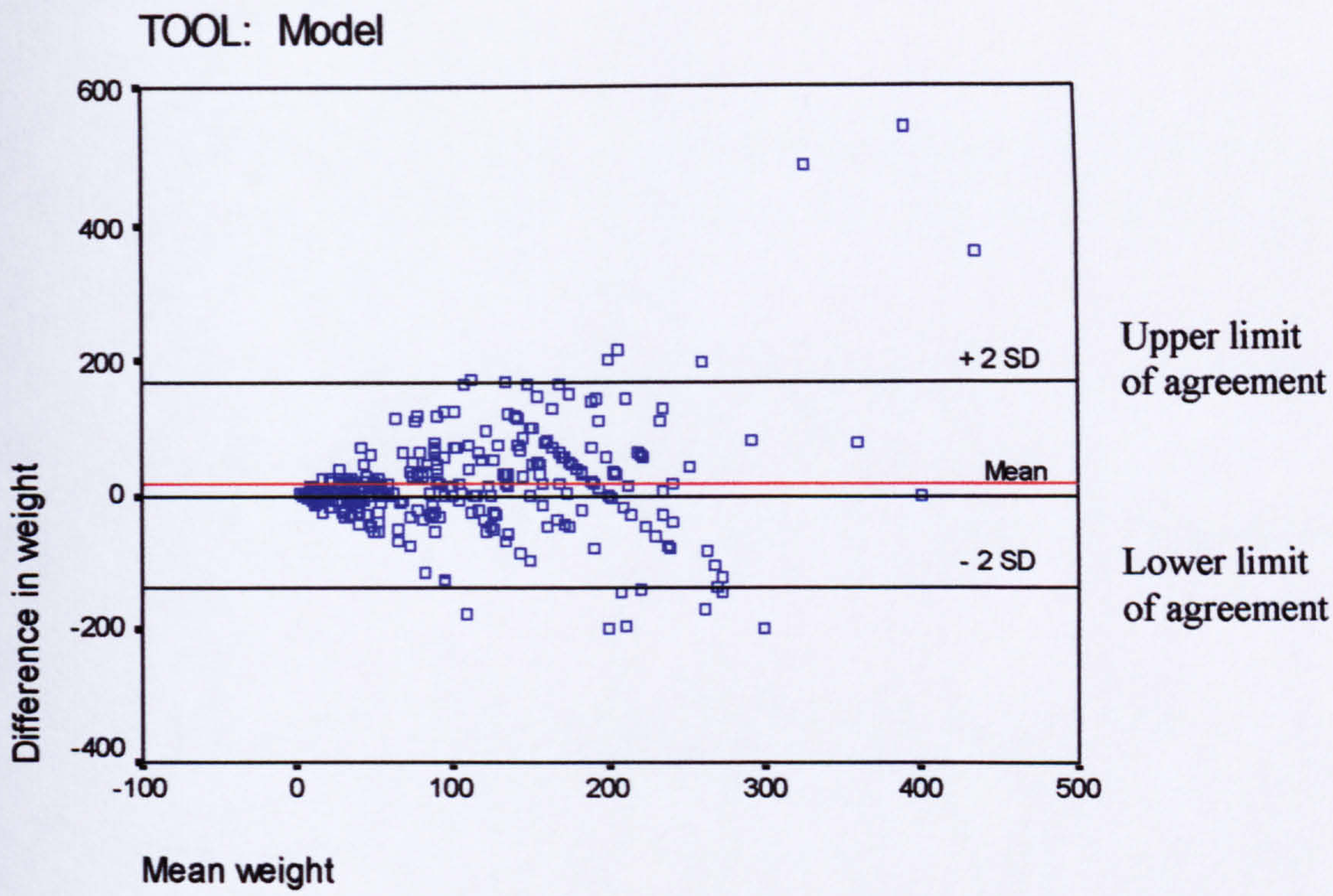


Figure 5.1 Plot of difference between the child's estimate of portion size(g) using food models and the actual weight(g) against the mean of these two weights (n= 328 estimates)

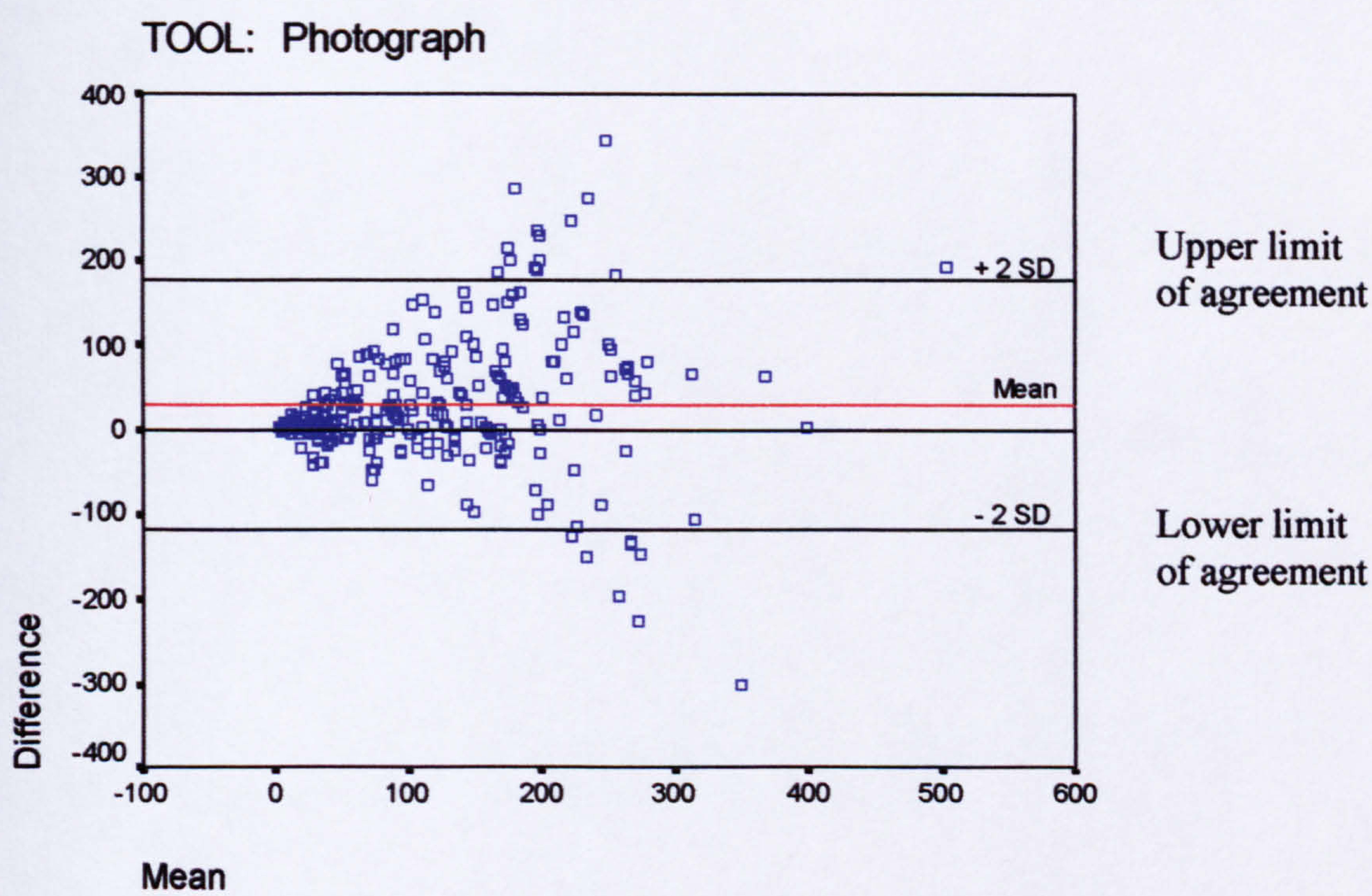


Figure 5.2 Plot of difference between the child's estimate of portion size(g) using food photographs and the actual weight (g) against the mean of these two weights (n=307 estimates)

- **Precision of portion size estimates - Bland Altman Plots to show the limits of agreement for the food models and food photographs in estimating portion size – By age**

As might be expected the limits of agreement for both the food models and the food photographs were wider for the younger children indicating that the precision of estimates of portion size was poorer for the younger compared with the older children.

The 5 to 6 year old children overestimated portion size by 22g on average (a percentage error of 55%) using the food models whereas the 10 to 11 year olds underestimated portion size by 9g (a percentage error of only 6%) The limits of agreement for the younger children using the food models were from 138g less than the actual weight of the food to 181g greater than the actual weight of the food (Figure 5.3). The limits of agreement for the older children using the food models were from 131g less than the actual weight of the food to 113g greater than the actual weight of the food (Figure 5.4).

The 5 to 6 year old children overestimated portion size by 39g on average (a percentage error of 76%) using the food photographs whereas the 10 to 11 year olds underestimated portion size by 0.5g (a percentage error of 25%). This high percentage error but low mean difference in terms of weight is likely to be due to one or two gross overestimates of very small items) The limits of agreement for the younger children using the food photographs were from 103g less than the actual weight of the food to 182g greater than the actual weight of the food (Figure 5.5). The limits of agreement for the older children using the food photographs were from 148g less than the actual weight of the food to 147g greater than the actual weight of the food (Figure 5.6).

Although accuracy and precision improved with age the performance of both tools was poor with both the younger and older children. The younger children were more precise in their estimates of portion size using the food photographs wereas the older children were more precise using the food models.

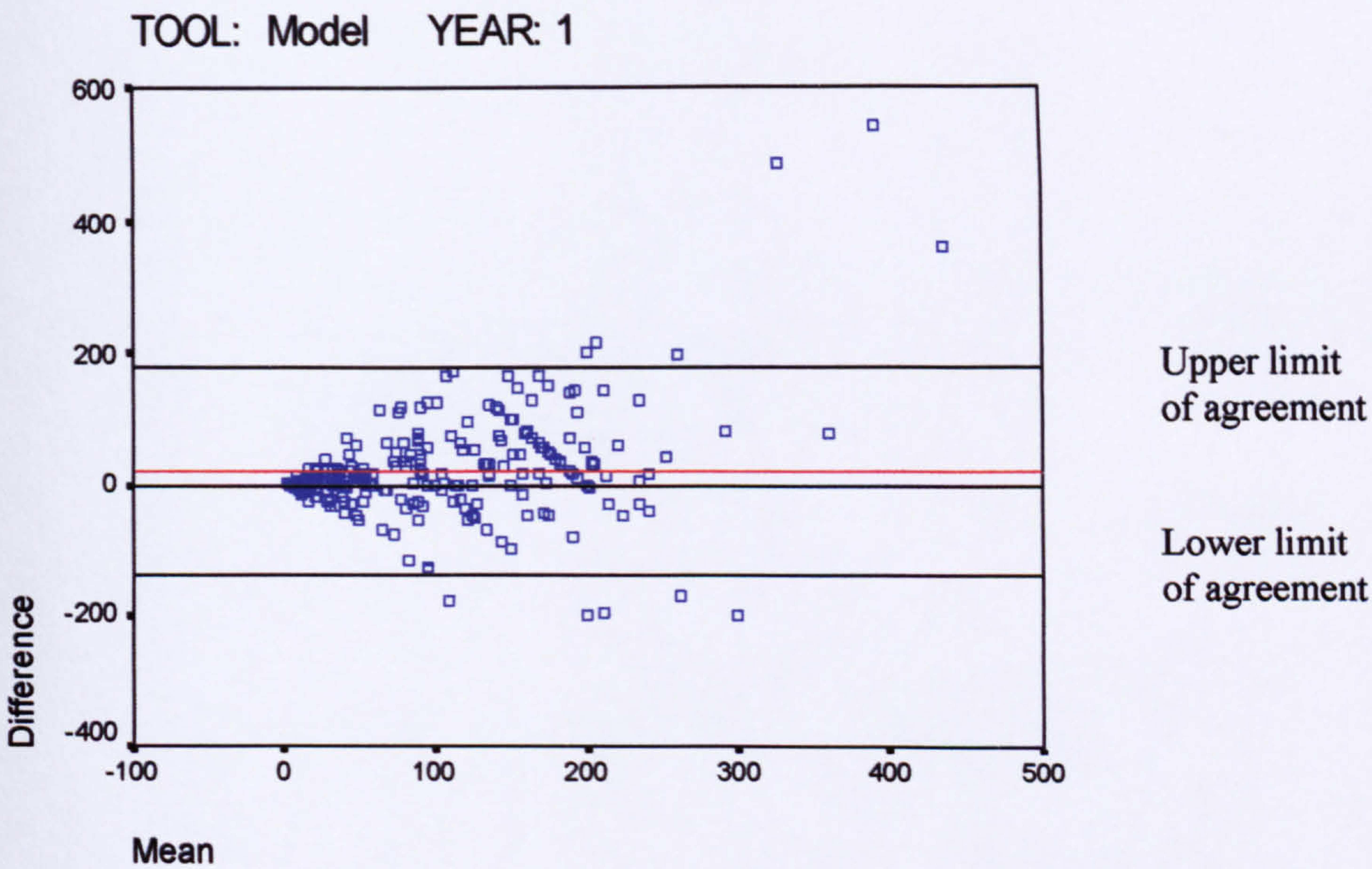


Figure 5.3 Plot of difference between the child's estimate of portion size(g) using food models and the actual weight(g) against the mean of these two weights - Year 1 children (n= 258 estimates)

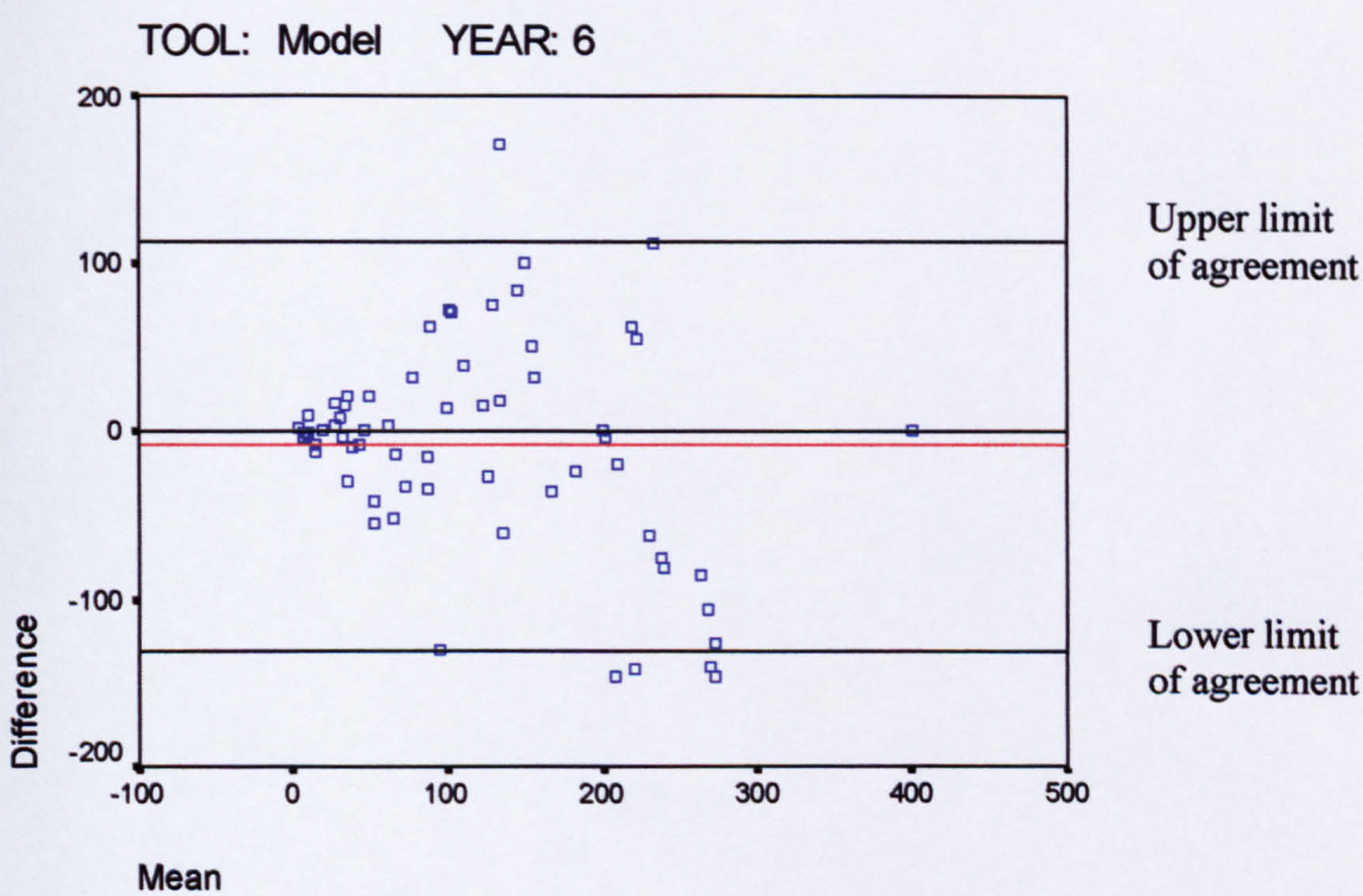


Figure 5.4 Plot of difference between the child's estimate of portion size(g) using food models and the actual weight(g) against the mean of these two weights - Year 6 children (n= 70 estimates)

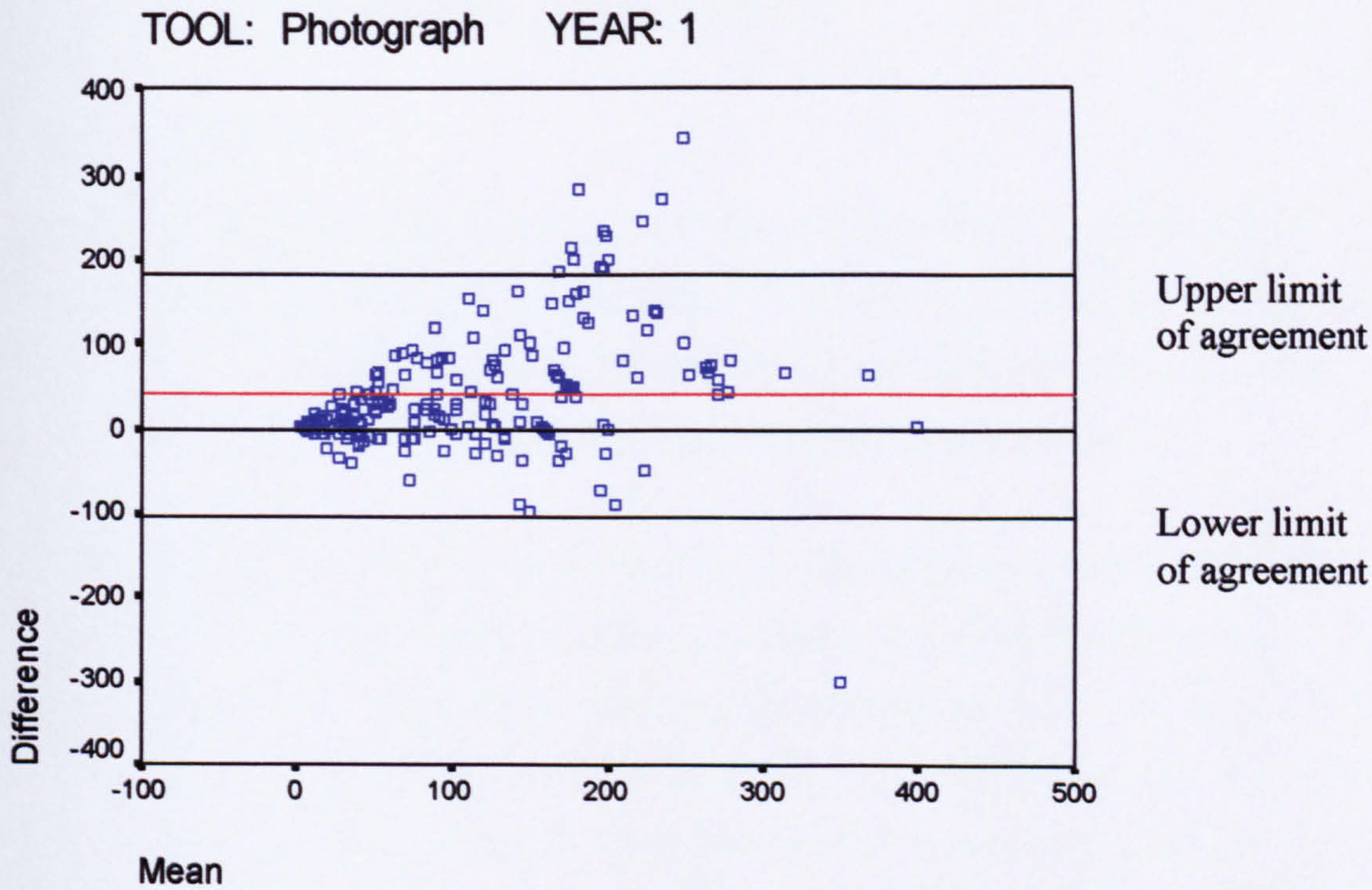


Figure 5.5 Plot of difference between the child's estimate of portion size(g) using food photographs and the actual weight(g) against the mean of these two weights - Year 1 children (n= 220 estimates)

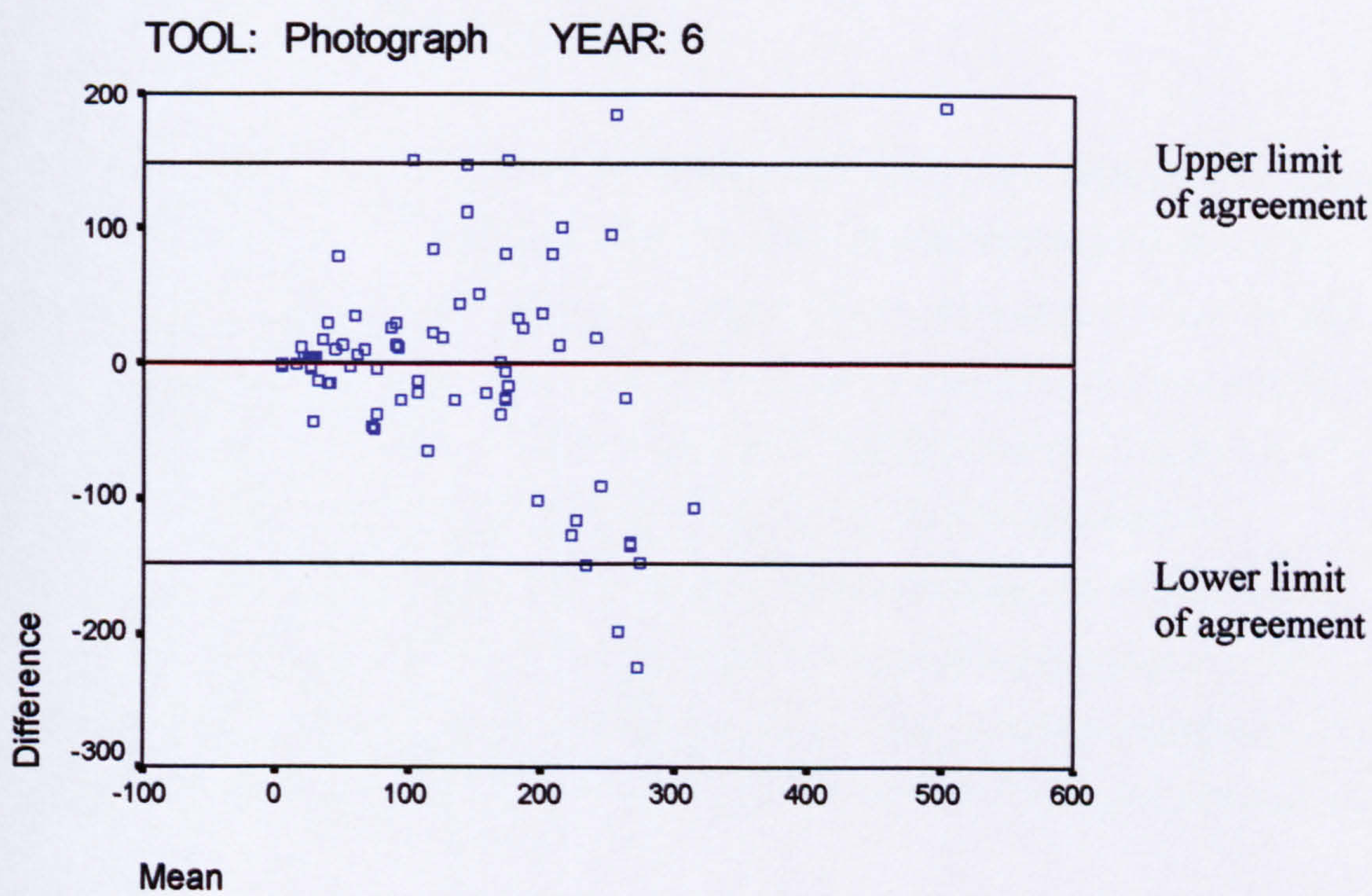


Figure 5.6 Plot of difference between the child's estimate of portion size(g) using food photographs and the actual weight(g) against the mean of these two weights - Year 6 children (n= 87 estimates)

5.6 School dinner diary (Approach 2)

5.6.1 Methods

An envelope containing the school dinner diary and a letter to the parent or guardian detailing what was required was distributed to all children consenting to complete a school dinner diary (Appendix 26). Children were given verbal instructions at school on keeping a record of their school dinner.

On the days on which the school dinner diary was to be completed each child participating in the study was assigned a number and given a sticker displaying this number to wear in the dinner hall to assist identification. Each child's dinner was photographed using a digital camera prior to the child sitting down to eat. At the end of their dinner each child returned to the researcher and any left-overs were photographed and each food item leftover was weighed. Individual school dinners were not weighed prior to consumption as this was not seen as practical in the school setting. To obtain reference weights 'test dinners' were collected each dinnertime and weighed to obtain average serving sizes for each food selected by the different age groups taking part in the study. Each individual child's leftovers were weighed.

Children were interviewed the day following each of the two days of recording to obtain an estimate of portion size for each of the foods recorded in the diary. One of the interviews was conducted using the food photograph atlas Nelson *et al.*, 1997 (Appendix 4) and one using food models (Appendix 19) to quantify portions. The order of the interviews was randomised in order to account for any potential learning effect which may have occurred. Foods reported as consumed at dinnertime were checked against the photograph of the school dinner to ensure that an estimate of portion size was being obtained for all foods consumed and not for any 'phantom' foods, that is foods reported in the school dinner diary which were not actually consumed or were not present on the plate.

- **Data Handling**

Information on participating children including name, date of birth, school class, gender and weight were entered into the ACCESS database. For each child's school dinner diary the date, name of food consumed and estimated weight were entered along with the aid used to estimate portion size (model or photo) at the interview. Information on the average weight of each food served at school dinner was entered along with date and food name. Queries within the database used the food name and date from both the school dinner information and the child's school dinner diary to match the foods to enable the child's estimate of the portion size for that food to be compared with the average weight served at school dinner on the relevant school day.

Coding of foods was conducted as described in paragraph 2.8.1 and 2.8.2

- **Data analysis**

The methods of Bland Altman (Bland and Altman, 1986) and percentage errors were used to compare the children's estimates of portion size with the weight of the average portion served as described in paragraph 4.8.5. Analysis of variance was used to examine whether there were any significant differences in ability to estimate portion size with portion size assessment tool, age, gender or test number.

5.6.2 Results of the school dinner diary

- **Accuracy of portion size estimation by portion size assessment tool, gender, age and test number**

For the school dinner data, as with the food diary data, the range of both types and portion sizes of foods consumed was too great to allow analysis by individual food type and therefore the results presented are based on all foods and all portion sizes combined.

Overall there was a trend for children to overestimate portion size. The mean percentage error for all children's estimates for all foods was 63% of the average weight served.

There was no significant difference in children's ability to estimate portion size using the models and photographs although there was a non-significant trend for accuracy to be slightly greater with the photographs (Table 5.7). There was no significant difference between boys' and girls' ability to estimate portion size although there was a trend for girls' estimates to be more accurate. The older children (year 6) were significantly more accurate in their estimation of portion size compared with the younger children (year 1) (p=0.01). The year 6 children's estimates were on average 123% of the actual weight of the food. The year 1 children's estimates were on average 216% of the actual weight of the food. There was no evidence for a learning effect with repeated portion size estimation, in fact accuracy was poorer on the second test (children estimated portion size on two occasions but using different methods).

Table 5.7 Error in children's estimates of portion size compared with actual weight from the school dinner data

Factor		Number of children	Percentage error	Mean ratio[1]	Standard error of the difference[2]	Sig p value
Tool	**Model**	60	77	1.77	0.390	0.295
	Photo	60	49	1.49		
Gender	**Male**	62	91	1.91	0.359	0.110
	Female	58	33	1.33		
Year	**1**	52	116	2.16	0.373	0.015
	6	68	23	1.23		
Test number	**1**	60	42	1.42	0.390	0.295
	2	60	84	1.84		
Overall mean		120	63	1.63		

1. Mean ratio is the mean ratio of the children's estimates of portion size to the actual weight of the portion size.
2. The standard error of the difference given is the standard error of the difference between the mean ratio of the estimated weight to the actual weight using the food models and the food photographs.

- **Age related differences in the accuracy of portion size estimation using each of the portion size assessment tools**

Table 5.8 Error in children's estimates of portion size compared with actual weight from the school dinner data – Year 1 compared with Year 6 children

Age group	Tool	Mean ratio	SD	p[1]	Mean diff between tools	95% CI	p[1]
Year 1	Models	2.55	4.351	0.443	0.70	-1.15, 2.55	0.404
	Photos	1.86	0.530				
Year 6	Models	1.16	0.314	0.362	-0.07	-0.21, 0.08	
	Photos	1.22	0.309				

[1]The p value given is the significance of the difference between the difference in performance of the tools for each age group.

There was no significant difference between the difference in performance of the portion size assessment tools by age. The older children were more accurate in their estimates of portion size using both of the tools. The accuracy of estimates of portion size made by the older children was similar for both of the tools. The younger children were more accurate in their estimates of portion size using the food photographs compared with food models however this difference was not significant (Table 5.8).

No evidence for an age-gender interaction was found.

- **Precision of portion size estimates - Bland Altman Plots to show the limits of agreement for the food models and food photographs in estimating portion size**

Children overestimated portion weight on average by 24.3g using the food models (Figure 5.7) and by 143g using the food photographs (Figure 5.8). The mean actual weight was 79.5g with weights ranging from 5g to 236g. The limits of agreement were narrower for the school dinner data (Approach 2) than for the food diary data (Approach 1). For the food models the limits of agreement are from 119g less than the actual weight of the food to 168g greater than the actual weight of the food (Figure 5.7). While the limits of agreement for the food photographs are from 81g less than the actual weight to 148g above the greater than (Figure 5.8).

TOOL: Model

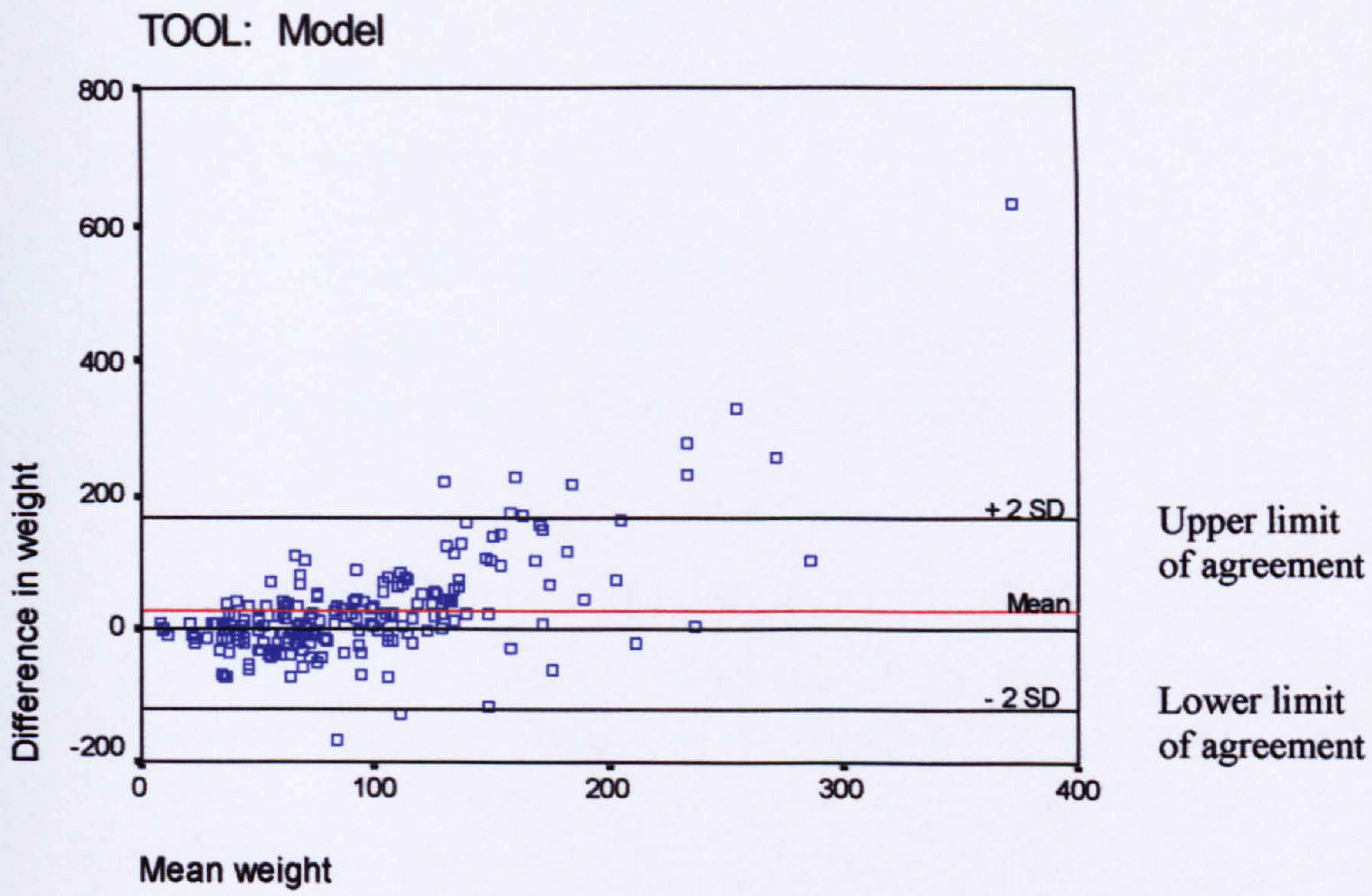


Figure 5.7 Plot of difference between the child's estimate of portion size (g) using food models and the actual weight (g) against the mean of these two weights (n= 273 estimates)

TOOL: Photograph

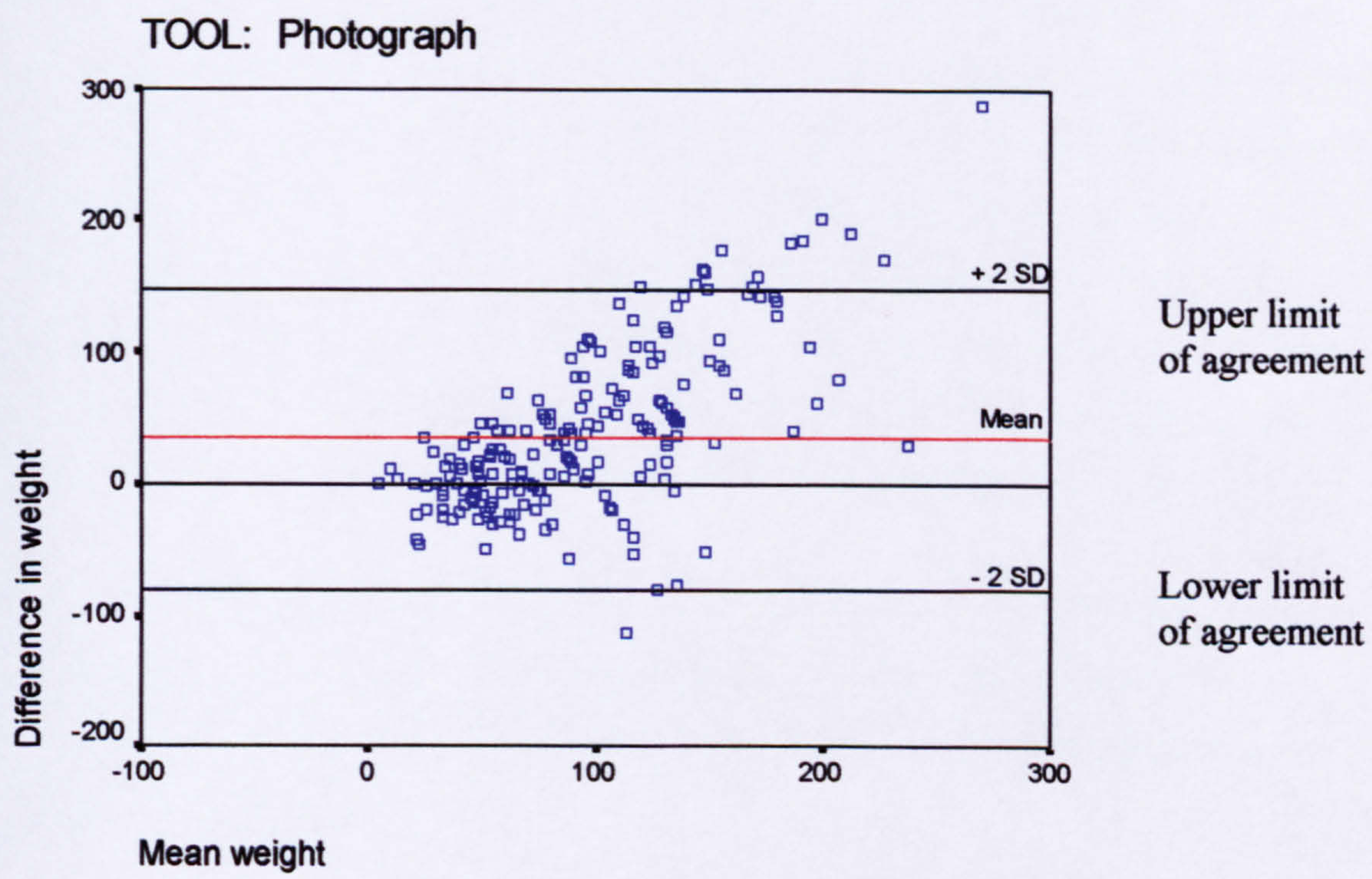


Figure 5.8 Plot of difference between the child's estimate of portion size(g) using food photographs and the actual weight (g) against the mean of these two weights (n= 274 estimates)

- **Precision of portion size estimates - Bland Altman Plots to show the limits of agreement for the food models and food photographs in estimating portion size**

Again the limits of agreement for both the food models and the food photographs were wider for the younger children indicating that precision of estimates of portion size was poorer for the younger compared with the older children.

The 5 to 6 year old children overestimated portion size by 45g on average (a percentage error of 69%) using the food models whereas the 10 to 11 year olds underestimated portion size by 12g (a percentage error of 31%) The limits of agreement for the younger children using the food models were from 147g less than the actual weight of the food to 237g greater than the actual weight of the food (Figure 5.9). The limits of agreement for the older children using the food models were from 87g less than the actual weight of the food to 112g greater than the actual weight of the food (Figure 5.10).

The 5 to 6 year old children overestimated portion size by 62g on average (a percentage error of 86%) using the food photographs whereas the 10 to 11 year olds underestimated portion size by 18g (a percentage error of 30%) The limits of agreement for the younger children using the food photographs were from 77g less than the actual weight of the food to 201g greater than the actual weight of the food (Figure 5.11). The limits of agreement for the older children using the food photographs were from 66g less than the actual weight of the food to 103g greater than the actual weight of the food (Figure 5.12).

Precision of estimates by both age groups was greater using the food photographs compared with the food models. However, the precision of estimates using both tools was poor for both age groups as evidenced by the wide limits of agreement.

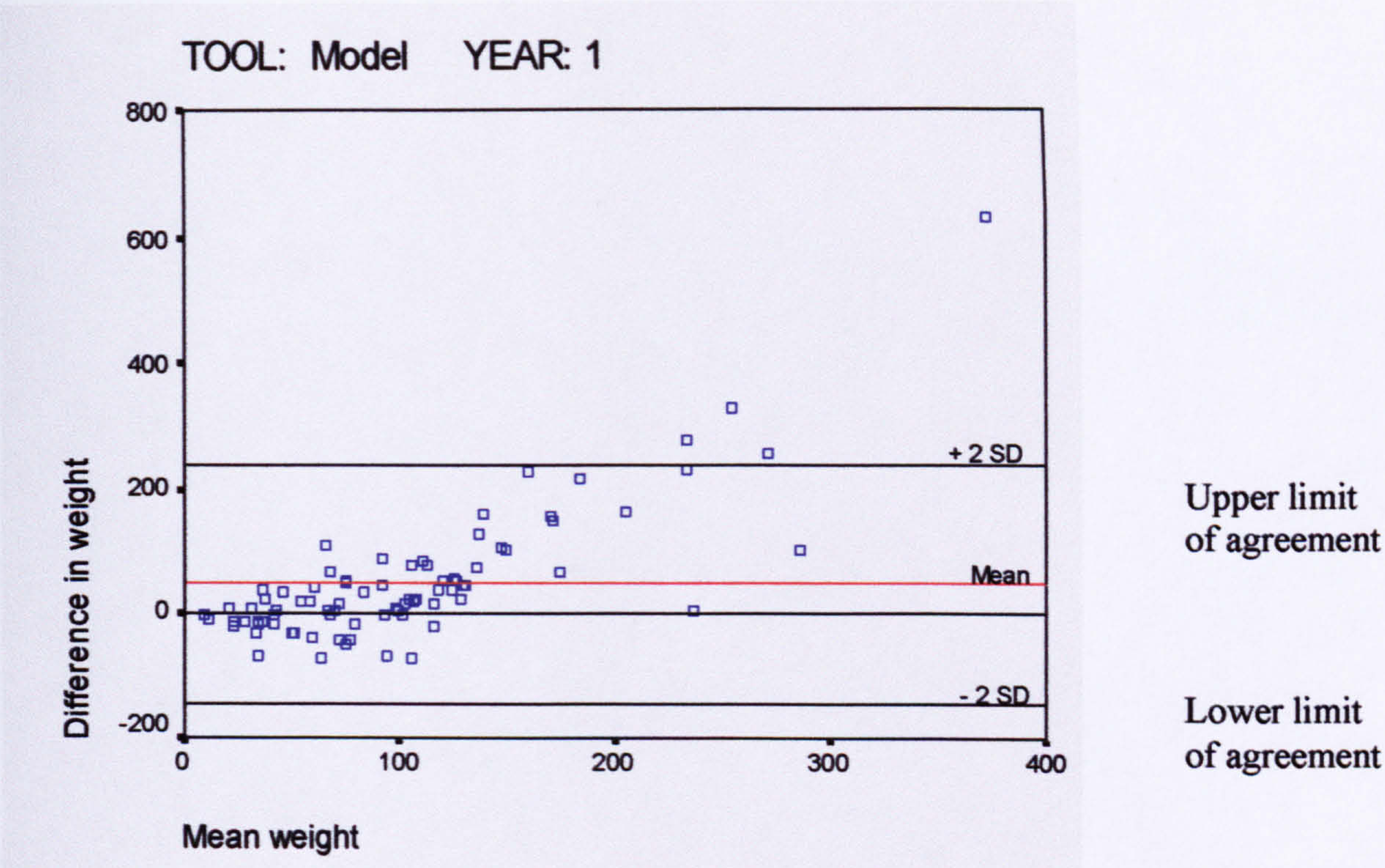


Figure 5.9 Plot of difference between the child's estimate of portion size (g) using food models and the actual weight (g) against the mean of these two weights – Year 1 (n= 98 estimates)

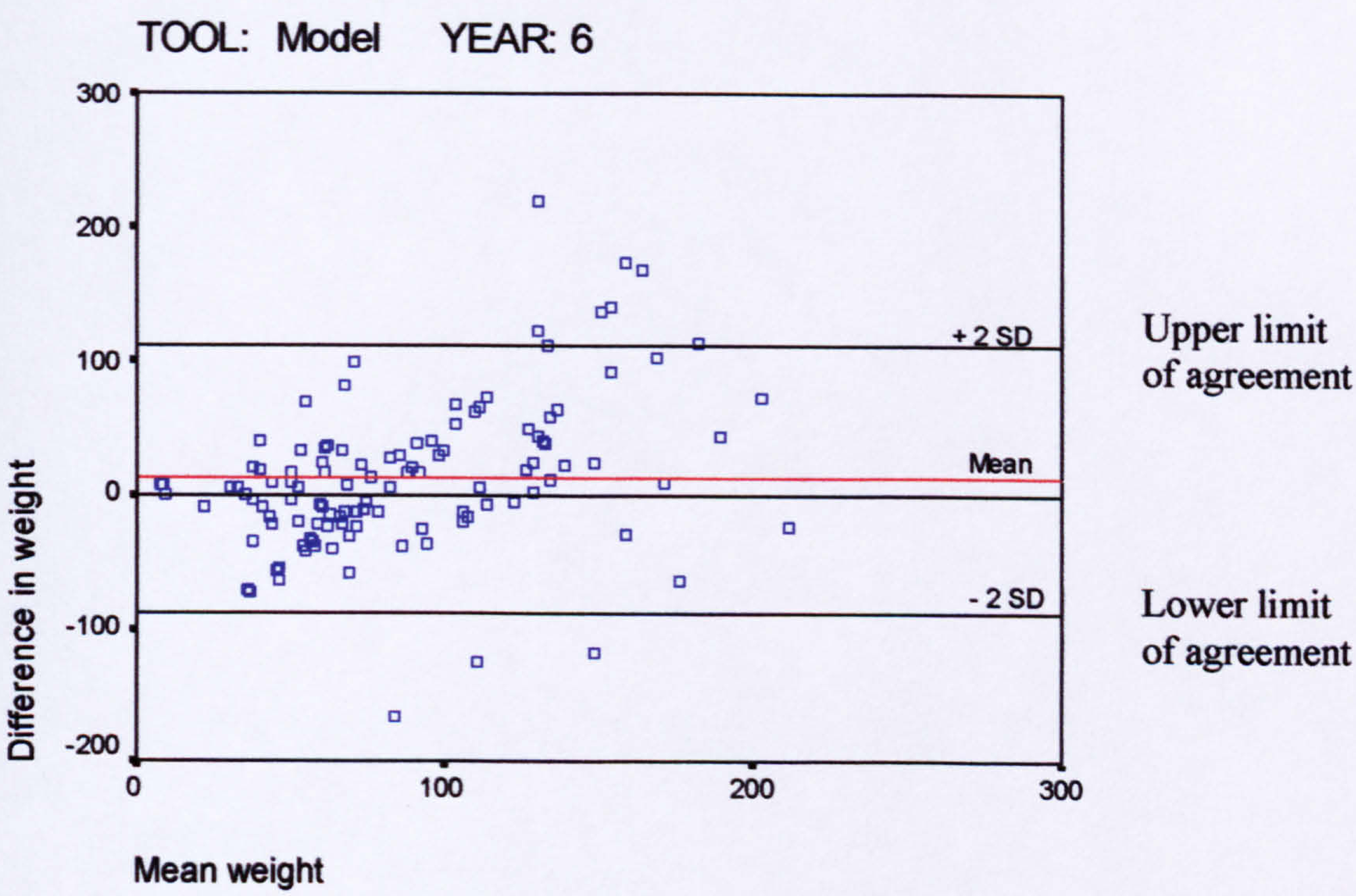


Figure 5.10 Plot of difference between the child's estimate of portion size (g) using food models and the actual weight (g) against the mean of these two weights – Year 6 (n= 172 estimates)

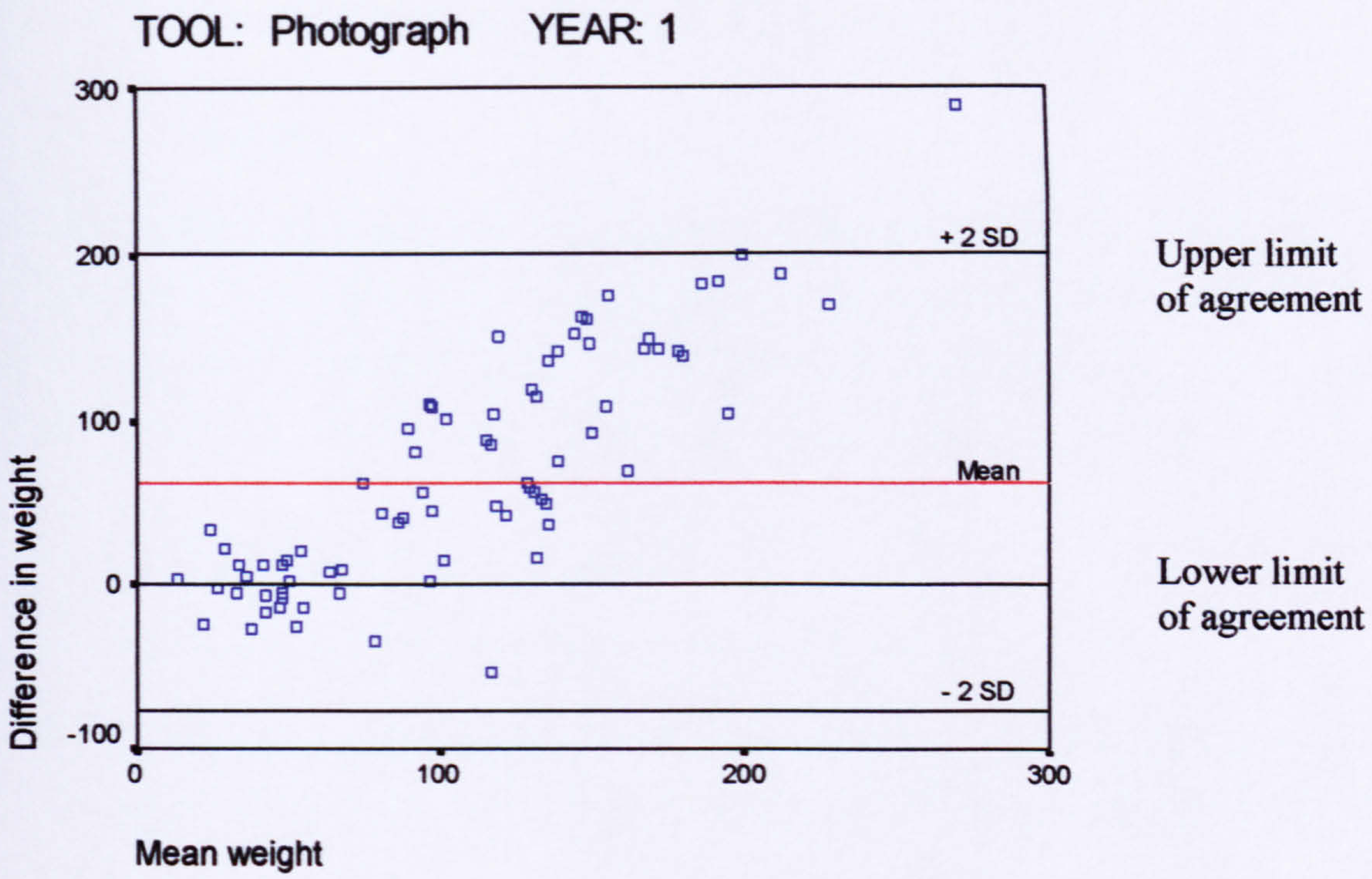


Figure 5.11 Plot of difference between the child's estimate of portion size (g) using food photographs and the actual weight (g) against the mean of these two weights – Year 1 (n= 94 estimates)

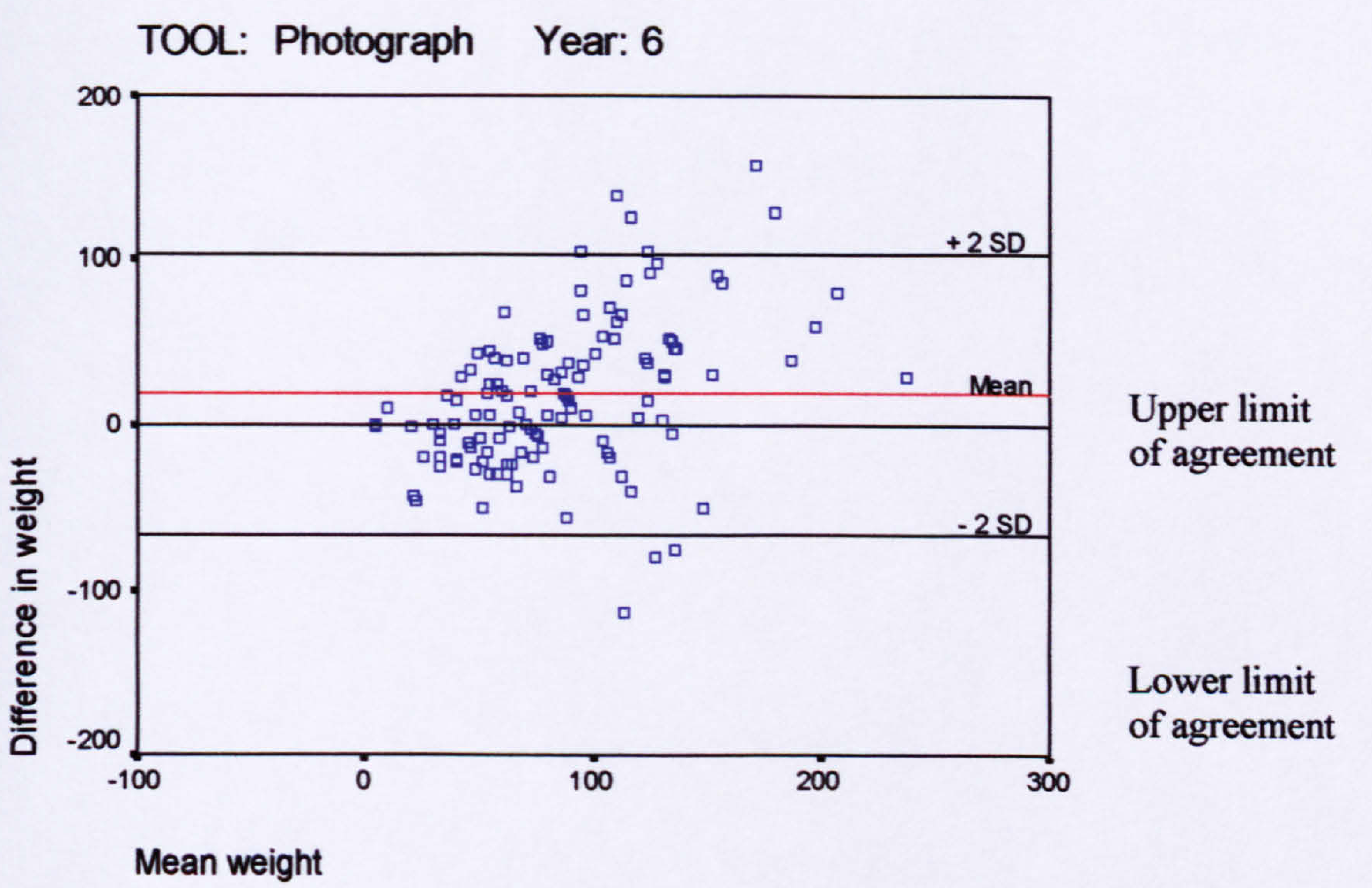


Figure 5.12 Plot of difference between the child's estimate of portion size (g) using food photographs and the actual weight (g) against the mean of these two weights – Year 6 (n= 180 estimates)

5.7 Portion size perception interview (Approach 3)

5.7.1 Methods

The aim of this part of the study was to collect a large number of estimates of portion size from children for the same foods under two conditions. These were done in an artificial situation where the child was asked to view, but not consume the food. This enabled a number of aspects to be controlled:

- All children saw the same foods
- The exact weight of each food seen was known
- Estimates were collected from the same child for the same food using two different portion size assessment tools to allow comparison of the utility of each tool
- **Foods**

Fifteen foods were chosen for the portion size interviews. These were those foods most commonly consumed by children in the fruit and vegetable intervention study (Chapter 4) which could not be quantified easily using brand information. They were selected to provide a range of solid, liquid and amorphous foods. Table 5.9 gives the rank of the most commonly consumed foods and the reasons for exclusion if they were not included in this study.

Table 5.9 Rationale for choosing foods to be presented during the portion size perception interview

Rank	Food	Included	Reason for exclusion	Properties
1	Cold drinks	Yes		Liquid
2	Spread	No	Could not be done using models	
3	Bread	Yes		Solid item
4	Crisps	No	Easily quantified from brand information	
5	Cereal (milk)	Yes		Mixture
6	Sweets	No	Easily quantified from brand information	
7	Chips	Yes		Solid multiple items
8	Biscuits	No	Easily quantified from brand info	
9	Potatoes (mashed)	Yes		Amorphous
10	Apples	Yes		Solid item
11	Cake	Yes		Solid item
12	Bread rolls	No	Bread already included	
13	Meat slices (ham)	Yes		Solid item
14	Chocolate bars	No	Easily quantified from brand information	
15	Yoghurt	No	Easily quantified from brand information	
16	Sugar	No	Difficult to present as consumed e.g. in tea/on cereal	
17	Sauce (ketchup)	Yes		Amorphous
18	Hot drinks	No	Liquids already covered	
19	Sausages	Yes		Solid multiple items
20	Chocolate biscuits	No	Easily quantified from brand information	
21	Banana	Yes		Solid item
22	Cheese (cheddar)	Yes		Solid item
23	Baked beans	Yes		Amorphous / mixture
24	Pasta (macaroni cheese)	Yes		Amorphous / mixture
25	Ice cream	Yes		Amorphous

The foods were presented in combination so that the children saw plates of foods which would commonly be consumed together. The plates of foods were:

- Chips and tomato ketchup
- Ham, bread and cheese
- Sausage, mashed potato and baked beans
- Rice Krispies and milk
- Apple and banana
- Cake and ice cream
- Macaroni cheese
- Orange squash

Portion sizes were determined using the size of portions reported during the Fruit and vegetable intervention study (chapter 4). Three portion sizes representing the 25th, 50th and 75th percentile of the portion sizes consumed for that particular food were prepared for each food. These were considered 'small', 'medium' and 'large' portions. Three 'portion mixes' were developed each containing a mixture of small medium and large portions of the 15 different foods (Appendix 27). Each child was assigned to one portion mix and only saw one portion size for each food.

- **Interviews**

Foods of known weight were presented to children in a one-to-one interview situation. Children were given either the food photographs or food models and asked to use them to indicate the size of the portion of food presented. This was done under two conditions:

- Condition 1 - with the food in view, the 'food in front interview'
- Condition 2 - having seen the food the previous day, the '24hr recall interview.'

The children were seen on 4 occasions as each child was interviewed under the two conditions using the food models and the food photographs. Children were randomised to one of four interview orders to account for any learning effect which may have occurred (Table 5.10).

Table 5.10 Order of administration of interviews

Test	Interview order 1	Interview order 2	Interview order 3	Interview order 4
1	FIF photo	24hr recall photo	FIF model	24hr recall model
2	24hr recall photo	FIF photo	24hr recall model	FIF model
3	FIF model	24hr recall model	FIF photo	24hr recall photo
4	24hr recall model	FIF model	24hr photo	FIF photo

The study design is summarised in Figure 5.13. Sixty children were recruited to take part in the study, 30 from Year 1 (5 to 6 year olds) and 30 from Year 6 (10 to 11 year olds). Half of the children were interviewed using the food models first and half with the food photographs first. Each group was then divided further and half of the children completed the food in front interview first and half the 24hr recall interview first. Children within these groups were then assigned to one of three portion mixes which contained a mixture of small medium and large portions of the foods included in the study.

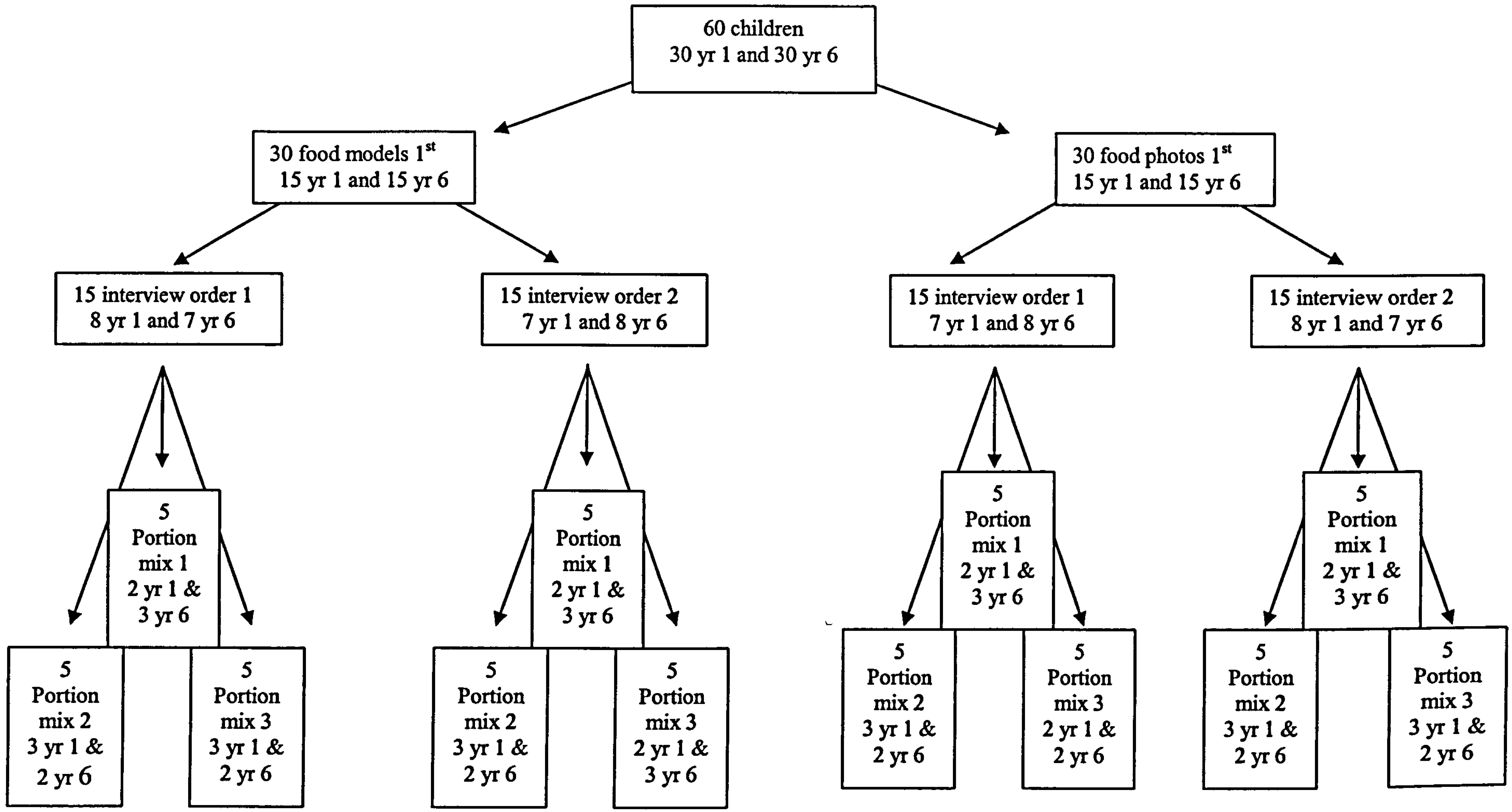
- **Data Handling**

Information on participating children including name, date of birth, school class, and gender were entered into the ACCESS database. Information collected during the interview was entered onto the database. The number of the portion mix seen was entered along with the interview number, the portion size assessment aid used, whether the food was in view or had been seen the previous day and the child's estimate of the weight of the food. The weights for the foods in each portion mix were entered in a separate area of the database. Queries were set up within the database so that the actual weight of the food the child saw was automatically entered on the form with the rest of the interview data.

- **Coding**

The photograph selected by the child for each food was converted to a weight using the lookup table within the ACCESS database (paragraph 3.8.2 pilot study). For foods not covered by the atlas such as Rice Krispies, a conversion factor was applied to the photograph used (in this case Cornflakes). For the food models no such list of weights were available therefore foods were prepared and if appropriate cut to the shape and size of the model. The average of ten spoonfuls, cupfuls, bowlfuls or model size pieces of the foods seen by the children were weighed and the average weight was used to produce a database of food portion weights represented by the models for a variety of foods.

Figure 5.13 Portion size interview study design



Interview order 1 is food in front interview first, 24hr recall interview second.
Interview order 2 is 24hr recall interview first, food in front interview second.
See Appendix 27 for details of the portions mixes

- **Data analysis**

The weights selected using the food photographs and models for the foods presented were compared with the known weights. The method of Bland Altman (Bland and Altman, 1986) was used to measure the agreement between children's estimates of portion size and the actual weight of the portion. In addition a multi-level ANOVA model was built for each food type. The model consisted of a between-child level (with constant gender and school-year for each child) and a within-child level (with each of the 4 combinations of portion size assessment aid type and timing of estimate running in a randomised order for each child). Models were fitted using the statistical package GenStat.

Percentage error was calculated for each portion size estimate using the formula:

(estimated weight – actual weight)*100 / actual weight.

A comparison of the data collected during the portion size interview with that collected during a similar study with adults (Nelson, Atkinson et al. 1996) was also conducted. The adult data for this analysis were kindly made available by Dr Michael Nelson of Kings College London. The data were log transformed for this analysis as the data were not normally distributed.

5.7.2 Results of the portion size perception interview

All children saw the same 16 foods of known portion sizes, either, small, medium or large. This resulted in a large number of observations per food which allowed analysis to be conducted on all foods collectively and also for each individual food.

- **Precision of portion size estimates - Bland Altman Plots to show the limits of agreement for the food models and food photographs in estimating portion size**

As found in Approaches 1 and 2 children consistently overestimated portion size on average using both the food models and the food photographs. Children overestimated portion weight on average by 23g using the food models and by 37g using the food photographs. The mean actual weight was 92g with weights ranging from 10g to 263g. For the food models the limits of agreement are from 92g less than the actual weight of the food to 128g greater than the actual weight of the food (Figure 5.14). While the limits of agreement for the food photographs are from 72g less than the actual weight to 134g greater than the actual weight (Figure 5.15)

As with the food diary and school dinner diary data the limits of agreement for both the food models and the food photographs were narrower for the older children indicating better precision of estimates in this age group.

The 5 to 6 year old children overestimated portion size by 19g on average (a percentage error of 19%) using the food models. The 10 to 11 year old children overestimated portion size to a similar extent using this tool, 18g on average (a percentage error of 19%), however the precision of their estimates was better. The limits of agreement for the younger children using the food models were from 98g less than the actual weight of the food to 136g greater than the actual weight of the food (Figure 5.16). The limits of agreement for the older children using the food models were from 88g less than the actual weight of the food to 123g greater than the actual weight of the food (Figure 5.17).

The 5 to 6 year old children overestimated portion size by 38g on average (a percentage error of 45%) using the food photographs. The 10 to 11 year old children overestimated portion size by 27g (a percentage error of 28%) using the food photographs. The limits of agreement for the younger children using the food photographs were from 73g less than the actual weight of the food to 149 g greater than the actual weight of the food (Figure 5.18). The limits of agreement for the older children using the food photographs were from 70g below the actual weight of the food to 124g greater than the actual weight of the food (Figure 5.19).

Again precision and accuracy were seen to improve with age. Both age groups were more accurate in their estimates of portion size using the food models but precision of the estimates was marginally better using the food photographs.

- **Precision of portion size estimation - Percentage of children correct to within a given % of the actual weight of the food**

46% of the children's estimates using food models and 43% of the estimates using photographs were correct to within 30% of the actual weight of the food. Only 23% of the children's estimates using food models and 22% of the estimates using food photographs were correct to within 10% of the actual weight of the food.

The year 1 children were correct to within 30% of the actual weight of the food for 44% of the estimates using food models and 34% of the estimates using photographs. Only 21% of the estimates using food models and 17% of the estimates using food photographs were correct to within 10% of the actual weight of the food.

The year 6 children were correct to within 30% of the actual weight of the food for 48% of the estimates using either the food models or the food photographs. Only 24% of the estimates using food models and 25% of the estimates using food photographs were correct to within 10% of the actual weight of the food (Figure 5.20).

- **Analysis by food type**

It is possible that the morphology of food may impact on the accuracy with which estimations of portion size are made. The number of estimates collected for each food allowed a comparison of the accuracy of children's estimates of portion size for different food types (Table 5.8).

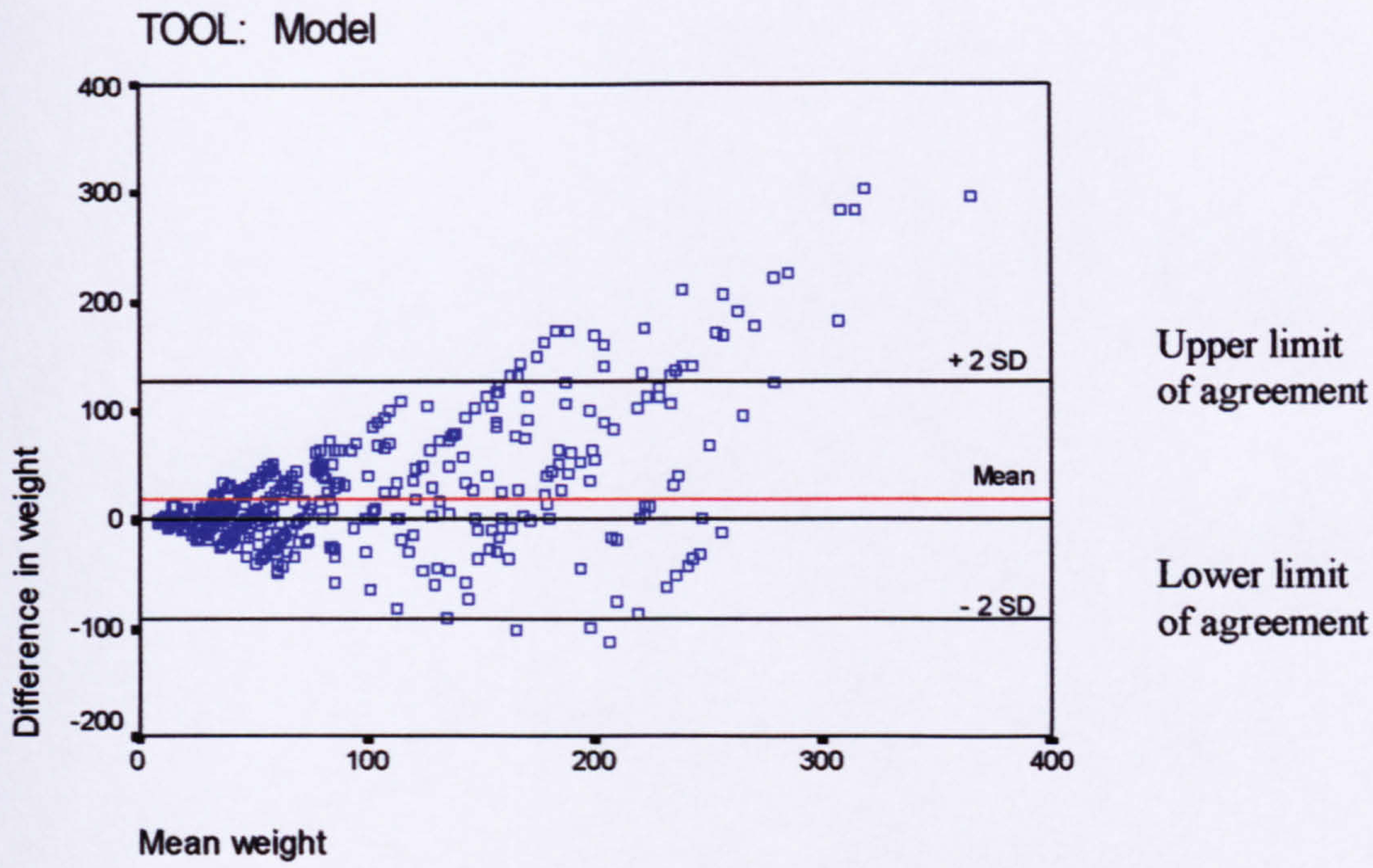


Figure 5.14 Plot of difference between the child's estimate of portion size(g) using food models and the actual weight (g) against the mean of these two weights (n= 1524 estimates)

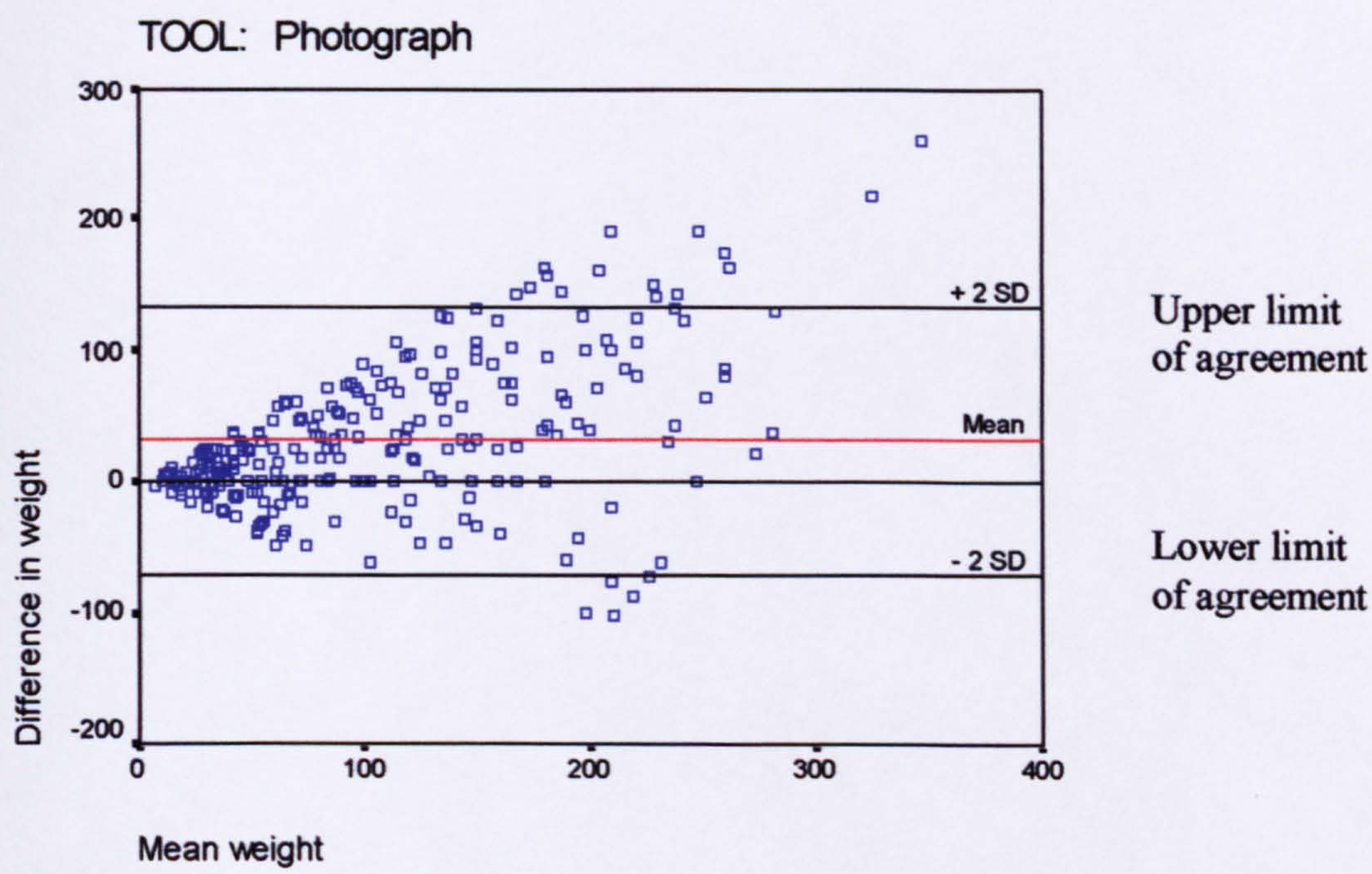


Figure 5.15 Plot of difference between the child's estimate of portion size(g) using photographs and the actual weight (g) against the mean of these two weights (n= 1633 estimates)

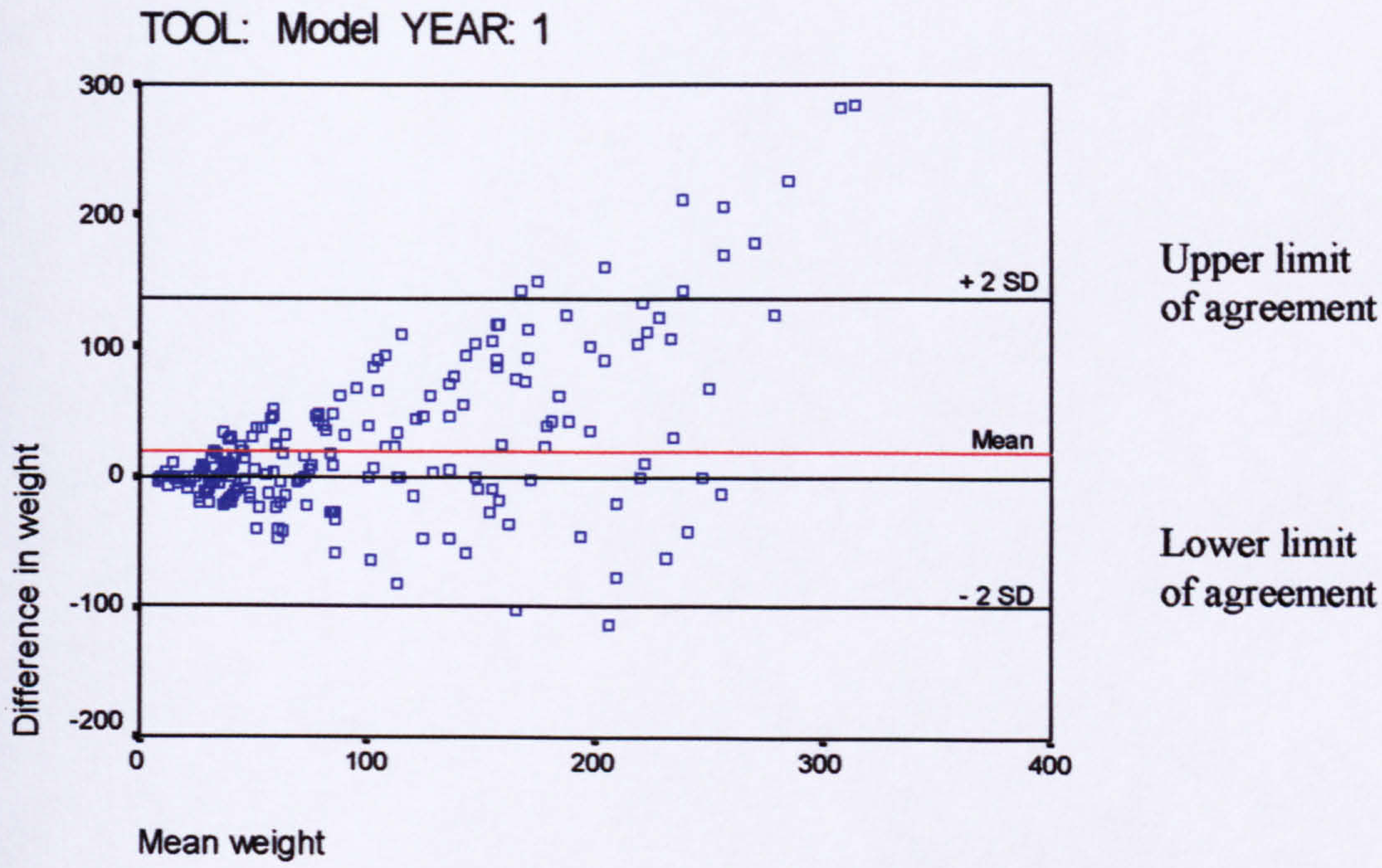


Figure 5.16 Plot of difference between the child's estimate of portion size(g) using food models and the actual weight (g) against the mean of these two weights – Year 1 children (n= 554 estimates)

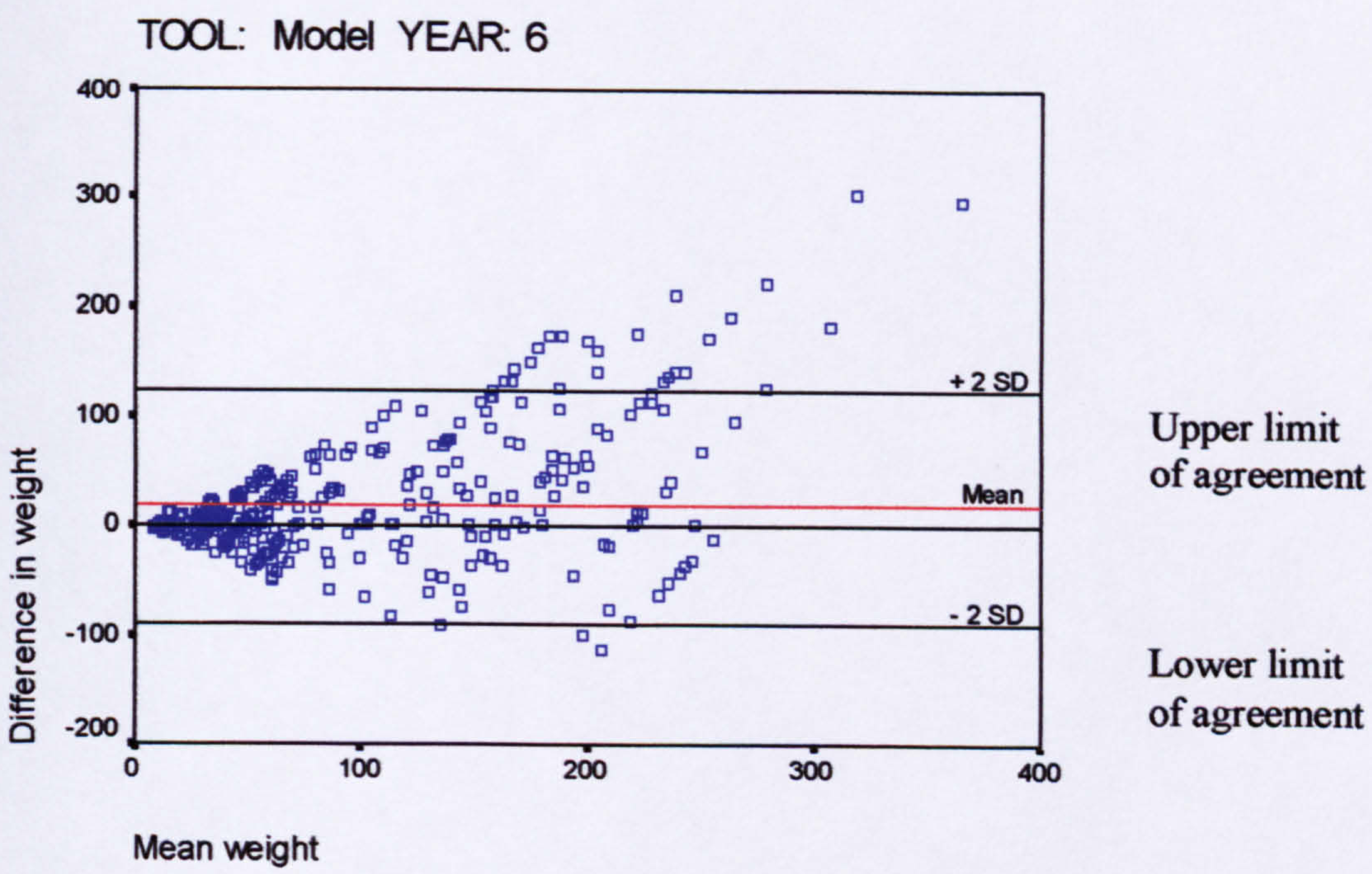


Figure 5.17 Plot of difference between the child's estimate of portion size(g) using food models and the actual weight (g) against the mean of these two weights – Year 6 children (n= 970 estimates)

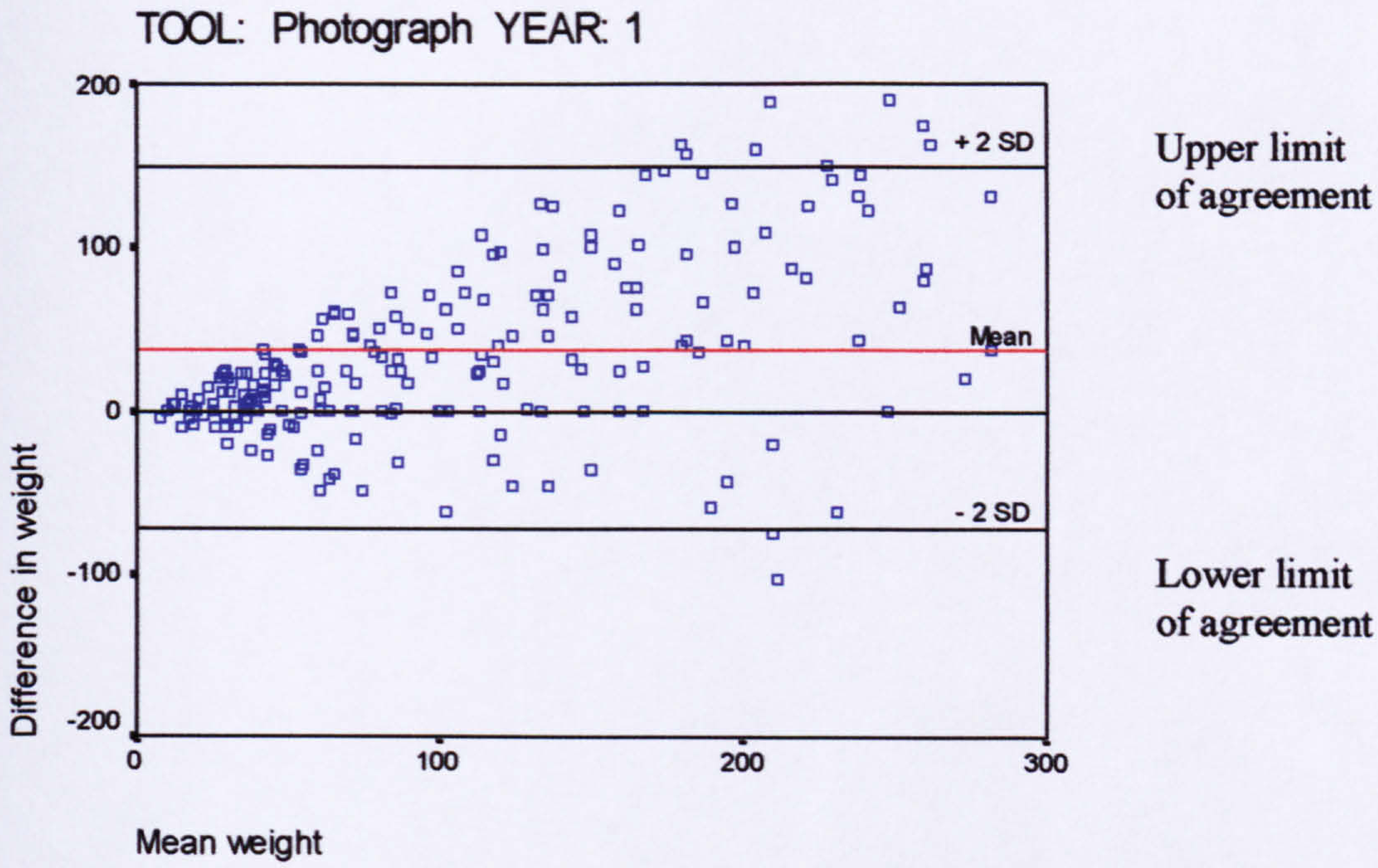


Figure 5.18 Plot of difference between the child's estimate of portion size(g) using photographs and the actual weight (g) against the mean of these two weights – Year 1 children (n= 611 estimates)

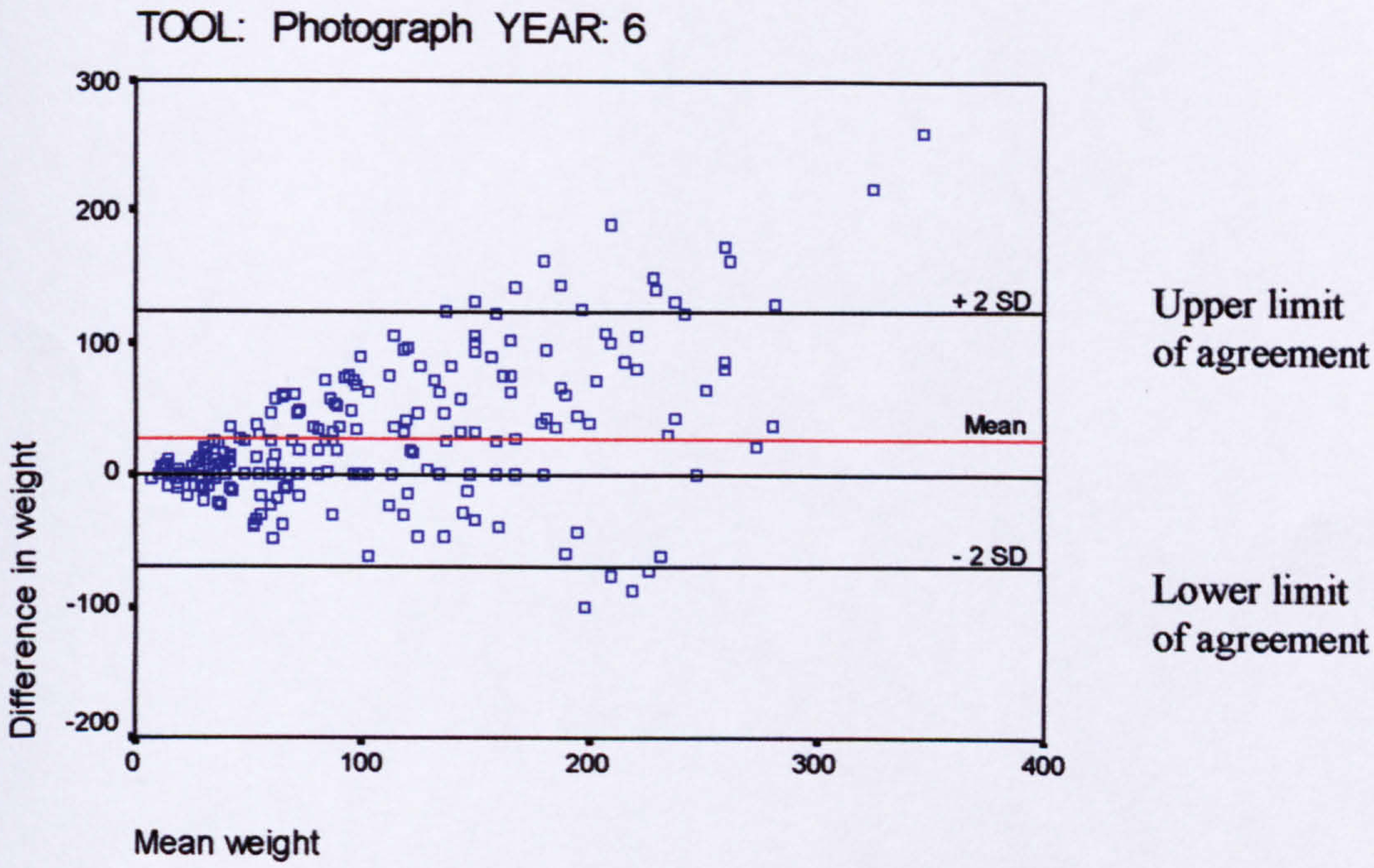


Figure 5.19 Plot of difference between the child's estimate of portion size(g) using photographs and the actual weight (g) against the mean of these two weights – Year 6 children (n= 1022 estimates)

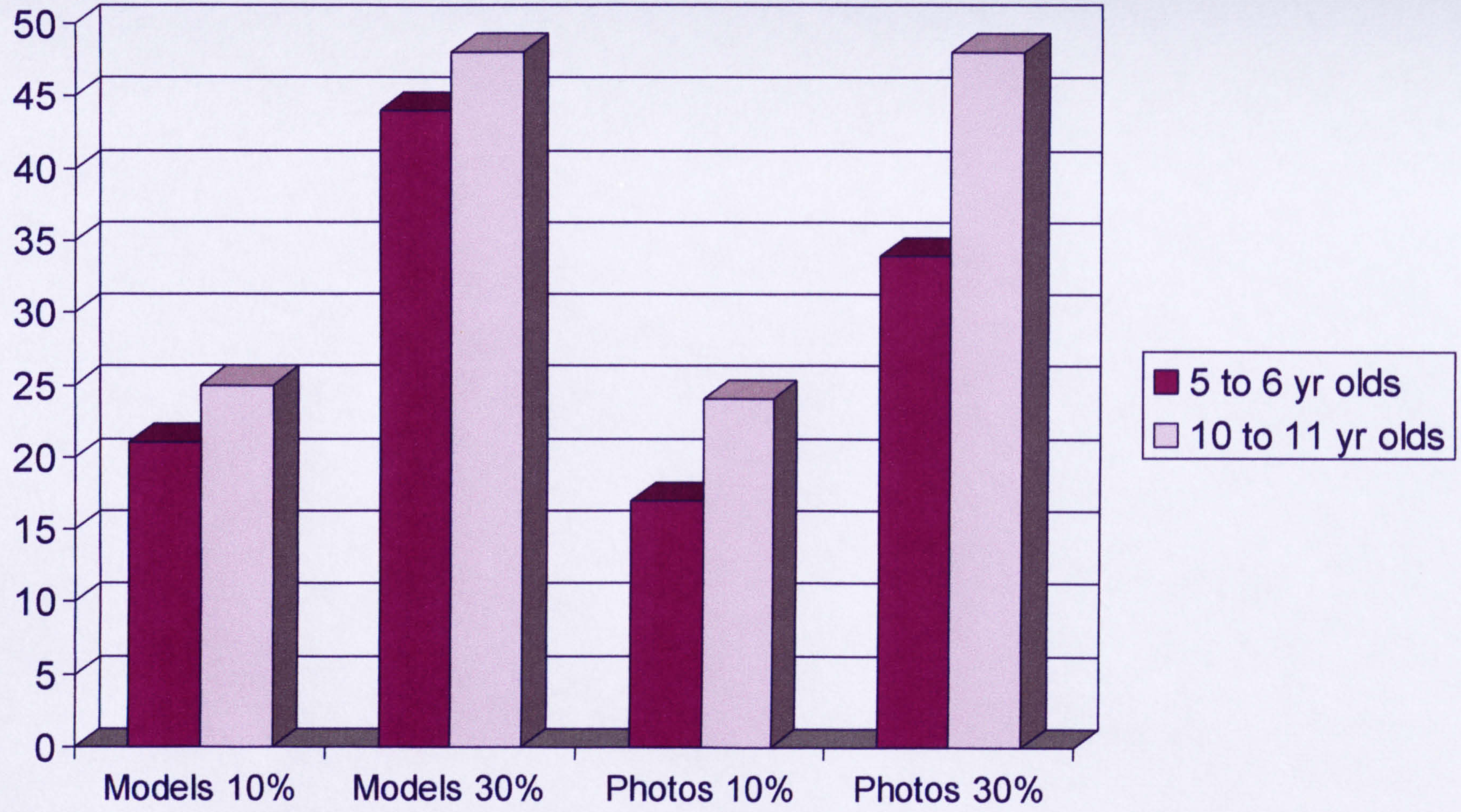


Figure 5.20 Proportion of estimates correct to within 10% and 30% of the actual weight of the food using food models and food photographs by 5 to 6 yr olds and 10 to 11 yr olds

Table 5.11 Ratio of the child's estimated weight to the actual weight of the food – analysis by food type, gender, age and portion size assessment tool

Food	No. of estimates	Overall mean ratio	Male	Female	P of diff male and female	Year 1	Year 6	P of diff yr 1 and yr 6	Photos	Models	P of diff models and photos
Apple	216	1.18	1.16	1.19	0.740	1.21	1.16	0.489	1.16	1.20	0.192
Banana	216	1.05	1.00	1.09	0.096	1.05	1.05	0.963	1.04	1.06	0.470
Beans	216	1.39	1.39	1.38	0.936	1.65	1.22	0.011	1.30	1.47	0.166
Bread	216	0.68	0.69	0.68	0.891	0.66	0.70	0.685	0.77	0.60	<0.001
Cake	216	1.31	1.20	1.39	0.078	1.40	1.25	0.186	1.59	1.02	<0.001
Cheese	216	1.52	1.62	1.44	0.073	1.55	1.50	0.628	1.56	1.48	0.347
Chips	216	2.11	2.12	2.10	0.929	2.29	2.00	0.097	1.85	2.37	<0.001
Ham	216	1.14	1.07	1.20	0.104	1.26	1.07	0.015	1.34	0.94	<0.001
Ice cream	216	0.97	0.99	0.96	0.562	1.04	0.93	0.097	1.31	0.64	<0.001
Ketchup	216	1.06	1.15	0.98	0.153	1.28	0.92	0.005	1.14	0.98	0.098
Rice krispies	216	1.17	1.22	1.13	0.192	1.30	1.09	0.008	1.23	1.11	0.004
Macaroni	216	1.64	1.69	1.61	0.581	1.81	1.54	0.098	1.88	1.41	<0.001
Milk	216	1.99	2.00	1.99	0.947	2.14	1.90	0.057	1.65	2.34	<0.001
Mash	216	1.44	1.49	1.41	0.567	1.67	1.30	0.010	1.74	1.15	<0.001
Sausages	216	1.98	2.15	1.85	0.469	2.30	1.78	0.220	2.69	1.27	<0.001
Squash	216	1.14	1.11	1.16	0.457	1.14	1.14	0.978	1.29	0.99	<0.001
All foods		1.36	1.38	1.35		1.48	1.28		1.47	1.25	

Table 5.11 shows girls were slightly more accurate in their estimates of portion size compared with boys but this difference was not statistically significant. Year 6 children were significantly more accurate in their estimates of portion size compared with Year 1 children for 6 out of the 16 foods included in the portions size perception interview. Over all foods Year 1 children estimated portion size to be 48% greater than the actual weight of the food and Year 6 children estimated portion size to be 28% greater than the actual weight of the food. No foods were significantly more accurately estimated by the younger children. Children were more accurate in their estimates of portion size using the food models (mean percentage error 25%) compared with the food photographs (mean percentage error 47%). Children estimated portion size of 7 of the 16 foods presented during the portion size perception interview more accurately using the food models than the food photographs. No difference was seen in the children's ability to estimate food portion size where foods were presented singly or in combination with other foods. No clear trends in children's ability to estimate portion size for different morphologies of food were seen.

A summary of the differences in portion size estimation with food type is given in the following section. For a detailed discussion see Appendix 28.

- **Summary of significant differences in portion size estimation by food type**

Analysis by gender		
	Boys	Girls
Percentage difference	38%	35%
Food more accurately estimated	No significant differences	

Analysis by age		
	Year 1	Year 6
Percentage difference	48%	28%
Food more accurately estimated		**6 out of 16**
		Baked beans
		Ham
		Tomato ketchup
		Rice krispies
		Milk
		Mashed potato

Analysis by tool		
	Photographs	Models
Percentage difference	47%	25%
Food more accurately estimated	**4 out of 16**	**7 out of 16**
	Bread	Cake
	Milk	Ham
	Chips	Rice krispies
	Ice cream	Macaroni cheese
		Mashed potato
		Sausages
		Squash

- **Age related differences in the accuracy of portion size estimation using each of the portion size assessment tools – by food**

Table 5.12 Error in children's estimates of portion size compared with actual weight from the Portion size interview – Year 1 compared with Year 6 children

Food	Age group	Tool	Mean ratio	p	SD	Mean diff between tools	95% CI	p[1]
Apple	Year 1	Models	1.20	0.668	0.332	-0.23	-0.13, 0.08	0.133
		Photos	1.22		0.370			
	Year 6	Models	1.20	0.062	0.271	0.08	0.00, 0.16	
		Photos	1.12		0.338			
Banana	Year 1	Models	1.04	0.880	0.274	0.00	-0.10, 0.08	0.480
		Photos	1.05		0.300			
	Year 6	Models	1.07	0.233	0.171	0.03	-0.02, 0.08	
		Photos	1.04		0.216			
Beans	Year 1	Models	1.81	0.280	1.835	0.32	-0.27, 0.90	0.422
		Photos	1.49		0.730			
	Year 6	Models	1.26	0.469	0.667	0.07	-0.12, 0.26	
		Photos	1.19		0.444			
Bread	Year 1	Models	0.57	<0.001	0.257	-0.19	-0.26, -0.12	0.649
		Photos	0.76		0.328			
	Year 6	Models	0.62	<0.001	0.284	-0.17	-0.22, -0.12	
		Photos	0.78		0.319			
Cake	Year 1	Models	0.83	<0.001	0.417	-1.11	-1.40, -0.82	<0.001
		Photos	1.94		1.017			
	Year 6	Models	1.14	0.048	0.518	-0.21	-0.42, 0.00	
		Photos	1.35		0.665			

Food	Age group	Tool	Mean ratio	p	SD	Mean diff between tools	95% CI	p[1]
Cheese	Year 1	Models	1.27	0.001	0.737	-0.56	-0.87, -0.26	0.404
		Photos	1.84		0.674			
	Year 6	Models	1.60	0.066	0.756	0.21	-0.01, 0.44	
		Photos	1.38		0.463			
Chips	Year 1	Models	2.33	0.617	0.938	0.09	-0.28, 0.47	0.001
		Photos	2.24		1.041			
	Year 6	Models	2.40	<0.001	0.755	0.80	0.60, 0.99	
		Photos	1.60		0.549			
Ham	Year 1	Models	0.99	<0.001	0.265	-0.53	-0.78, -0.28	0.167
		Photos	1.52		0.70			
	Year 6	Models	0.90	<0.001	0.320	-0.33	-0.48, -0.18	
		Photos	1.23		0.499			
Ice cream	Year 1	Models	0.67	<0.001	0.476	-0.74	-0.94, -0.53	0.321
		Photos	1.41		0.426			
	Year 6	Models	0.62	<0.001	0.255	-0.62	-0.71, -0.53	
		Photos	1.25		0.307			
Ketchup	Year 1	Models	1.22	0.555	1.001	-0.12	-0.54, 0.30	0.793
		Photos	1.35		0.949			
	Year 6	Models	0.83	0.052	0.434	-0.18	-0.37, 0.00	
		Photos	1.02		0.679			
Rice krispies	Year 1	Models	1.19	0.003	0.263	-0.23	-0.38, -0.08	0.022
		Photos	1.42		0.529			
	Year 6	Models	1.07	0.359	0.318	-0.04	-0.12, 0.04	
		Photos	1.10		0.317			

Food	Age group	Tool	Mean ratio	p	SD	Mean diff between tools	95% CI	p[1]
Macaroni	Year 1	Models	1.69	0.320	1.706	-0.25	-0.76, 0.25	0.174
		Photos	1.94		0.654			
	Year 6	Models	1.23	<0.001	0.457	-0.62	-0.77, -0.46	
		Photos	1.85		0.492			
Milk	Year 1	Models	2.39	0.001	0.812	0.50	0.23, 0.76	0.050
		Photos	1.89		0.545			
	Year 6	Models	2.32	<0.001	0.722	0.82	0.62, 1.03	
		Photos	1.49		0.531			
Mash	Year 1	Models	1.40	0.002	1.152	-0.54	-0.86, -0.21	0.627
		Photos	1.94		0.711			
	Year 6	Models	0.99	<0.001	0.389	-0.62	-0.79, -0.46	
		Photos	1.61		0.649			
Sausages	Year 1	Models	1.32	<0.001	1.389	-1.98	-2.94, -1.02	0.072
		Photos	3.30		3.397			
	Year 6	Models	1.24	<0.001	0.741	-1.06	-1.39, -0.73	
		Photos	2.30		1.626			
Squash	Year 1	Models	1.0	<0.001	0.210	-0.26	-0.35, -0.17	0.163
		Photos	1.27		0.366			
	Year 6	Models	0.98	<0.001	0.221	-0.33	-0.39, -0.27	
		Photos	1.31		0.328			

[1] The p value given is the significance of the difference between the difference in performance of the tools for each age group.

Which tool performed most accurately varied with the type of food. For 11 of the 16 foods the same tool proved most accurate for both age groups. The difference between the age groups in the difference in performance of the tools was significant for only a few foods. For estimates of the portion size of cake the performance of the tools was similar for the older children but significantly different for the younger children where models were more accurate than photos ($p<0.001$). For chips the accuracy of portion size estimates using both tools was similar for the younger children but significantly different for the older children who were more accurate in their estimates using the food photographs ($p<0.001$). Estimates of the portion size of Rice krispies using both tools were similar for the older children but significantly different for the younger children who were more accurate in their estimates of portion size using the food models ($p=0.003$).

The Year 1 children's estimates of food portion sizes were significantly different and more accurate for 7 foods using the food models (for ice cream the difference between tools was significant but one tool underestimated whilst the other overestimated). Estimates of food portion size, by the year 1 children, were significantly different and more accurate for 2 foods using the food photographs.

For the Year 6 children estimates were significantly different and more accurate using the food models for 5 foods (for ham the difference between tools was significant but one tool underestimated whilst the other overestimated). The older children's estimates of portion size were significantly different and more accurate for 4 foods using the food photographs (for ice cream the difference between tools was significant but one tool underestimated whilst the other overestimated). There was a trend for the food models to perform better with the younger children and the food photographs to perform better with the older children (Table 5.12).

- **Analysis by size of portion**

The portion size perception interview included small, medium and large portions of each food based on the 25th, 50th and 75th centile of weight of that food eaten by children taking part in the fruit and vegetable intervention study (Chapter 4). There were three portion mixes each of which contained a mixture of small medium and large portions of food. Each child was assigned to one portion mix and only saw one portion size for each food. This allowed analysis by size of portion to determine whether children's ability to estimate portion size differed with small, medium and large portion sizes of food.

Table 5.13 Percentage error in children's estimates of portion size compared with actual weight for small, medium and large portions

Portion size	Both methods percent error	Both methods difference in weight[1] (g)	Food models percent error	Food models difference in weight[1] (g)	Food photographs percent error	Food photographs difference in weight[1] (g)
Small	56.7	35.1	37.0	23.4	76.5	47.1
Medium	31.1	30.6	19.3	21.8	43.1	39.6
Large	20.6	24.7	19.2	24.8	21.9	24.6

[1] Difference in weight = estimated weight of portion – actual weight of portion

Children were more accurate in their estimations of large portions compared with small portions both in terms of the difference in weight between their estimate of the portion size and the actual weight of food shown and in terms of the difference as a percentage of the actual weight of the food (Table 5.13). Although more accurate in their estimations of the larger portions their estimate was still highly significantly different from the actual weight of the food, all differences were significant at the $p<0.001$ level. This trend was seen for both the food models and the food photographs and was evident for 12 out of the 16 foods.

- **Analysis by interview type**

Each child was required to complete portion size interviews for both the food models and the food photographs under two conditions; with the food in front of them, and the day after having seen the food (Section 5.7.1). This was to examine the effect of memory on portion size perception and conceptualisation.

Table 5.14 Ratio of the child's estimated weight to the actual weight of the food – analysis by food type and interview type.

Food	Number of estimates	Mean ratio Food in front	Mean ratio 24hr recall	p of difference in interview type
Apple	216	1.17	1.18	0.593
Banana	216	1.04	1.06	0.986
Beans	216	1.34	1.43	0.038
Bread	216	0.68	0.69	0.818
Cake	216	1.22	1.39	0.740
Cheese	216	1.47	1.57	0.582
Chips	216	2.09	2.14	0.940
Ham	216	1.13	1.15	0.901
Ice cream	216	0.94	1.01	0.531
Ketchup	216	1.08	1.04	0.848
Rice krispies	216	1.19	1.15	0.180
Macaroni	216	1.64	1.64	0.241
Milk	216	1.94	2.04	0.743
Mash	216	1.38	1.51	0.375
Sausages	216	1.98	1.98	0.128
Squash	216	1.15	1.13	0.513

Table 5.14 shows, for 11 out of the 16 foods presented in the portion size interview children's estimates of portion size were more accurate when the food was in front of them compared with 24hrs after having seen the food. However, this difference was significant for only one food, baked beans (P=0.038), indicating children's ability to estimate portion size is not greatly affected by memory.

- **Analysis by test number to determine whether estimates improved with repeated tests**

Randomisation of the order of tests ensured that tests 1 to 4 each include an equal mix of estimates made using food models and food photographs and with the food in front and 24hrs after having seen the food.

Table 5.15 shows, there was no clear learning effect with repeated tests. For only 3 out of the 16 foods (Apples, Baked beans and Tomato ketchup) did the error in portion size estimation consistently decrease with repeated tests. This difference was significant only for baked beans (p=0.015). Not only was there no learning effect but the children were relatively consistent in the degree of overestimation.

Table 5.15 Ratio of the child's estimated weight to the actual weight of the food – analysis by food type and test number

		Mean Ratio				
Food	Number of estimates	Test 1	Test 2	Test 3	Test 4	p of difference in test number
Apple	216	1.21	1.18	1.17	1.14	0.375
Banana	216	1.05	1.07	1.04	1.03	0.551
Beans	216	1.61	1.52	1.31	1.10	**0.015**
Bread	216	0.69	0.66	0.70	0.69	0.611
Cake	216	1.21	1.27	1.31	1.43	0.408
Cheese	216	1.48	1.56	1.54	1.50	0.930
Chips	216	2.14	2.09	1.97	2.24	0.199
Ham	216	1.04	1.16	1.20	1.17	0.201
Ice cream	216	0.98	1.04	0.93	0.95	0.334
Ketchup	216	1.20	1.08	0.94	1.02	0.277
Rice krispies	216	1.15	1.21	1.14	1.18	0.585
Macaroni	216	1.57	1.88	1.60	1.53	0.097
Milk	216	1.97	2.11	1.99	1.90	0.273
Mash	216	1.44	1.49	1.47	1.38	0.790
Sausages	216	1.90	2.17	1.89	1.97	0.694
Squash	216	1.14	1.13	1.13	1.17	0.547

5.8 Comparison of children's ability to estimate portion size with that of adults

Children's ability to estimate portion size using food photographs was compared with that of adults. The food photographs (Nelson, Atkinson et al. 1997) used in the pilot study (Chapter 3), the fruit and vegetable study (Chapter 4), and the study of the validity of methods for assessing food portion size with children (Chapter 5), were validated for use with adults (Nelson, Atkinson et al. 1994; Nelson, Atkinson et al. 1996) and the data from these studies were made available so comparisons between adult's and children's abilities could be made. Only those foods which were included in both studies were included in the comparison.

Table 5.16 shows children overestimated the portion sizes of all foods compared with the actual weight of the food. Adults' estimates of portion size were a mixture of over and under estimates of portion size with a mean ratio of 1 (i.e. on average there was no difference between the adult's estimate of the weight of the food and the actual weight of the food.) A comparison of Year 1 children's estimates of portion size with that of adults found children in Year 1 significantly overestimated the portion size of all foods compared with adults. Children in Year 6 were also found to significantly overestimate portion size compared with adults for all foods except for cheese, the food which adults overestimated the portion size of to the greatest degree.

Baked beans were well estimated and chips poorly estimated by all age groups however, there were no trends evident for the other 5 foods

Table 5.16 Ratio of the estimated weight to the actual weight of the food – a comparison of children's estimates with adult's estimates

	Year 1			Year 6			Adults			Sig of the diff between geometric mean ratio	
Food	No. of estimates	Mean Ratio	Geometric mean ratio	No. of estimates	Mean Ratio	Geometric mean ratio	No. of estimates	Mean Ratio	Geometric mean ratio	Adults and yr 1	Adults and yr 6
Beans	42	1.49	1.32	67	1.20	1.12	27	0.71	0.67	0.000	0.000
Cake	42	1.94	1.73	67	1.40	1.26	25	0.89	0.79	0.000	0.000
Cheese	42	1.84	1.73	67	1.39	1.30	24	1.34	1.27	0.001	0.735
Chips	42	2.24	2.02	67	1.62	1.54	16	1.13	1.10	0.000	0.000
Ham	42	1.40	1.40	67	1.23	1.16	16	0.96	0.86	0.000	0.036
Ice cream	42	1.41	1.34	67	1.23	1.20	30	1.08	1.01	0.001	0.006
Mash	42	1.94	1.81	67	1.62	1.51	16	0.94	0.91	0.000	0.000
All foods	294	1.77	1.60	469	1.38	1.29	154	1.00	0.92	0.000	0.000

5.9 Discussion

In this chapter the accuracy and precision of two methods used with children to estimate food portion size were tested using three approaches. Approach 1 a 2-day weighed food diary, Approach 2 a 2-day school dinner diary and Approach 3 a portion size perception interview. In addition the ability of children to estimate portion size using the food photographs was also compared with adult's ability to assess the portion size of the same foods using the same tool.

5.9.1 Portion size assessment tool differences

In the studies presented in this chapter the children performed better using the food models compared with the food photographs both in terms of difference in weight and percentage error. In a study of portion size estimation by adults (Kirkaldy-Hargreaves, Lynch et al. 1980) found the reverse was true with adults estimates being more accurate using food photographs compared with food models. However, the photographs used by Kirkaldy-Hargreaves *et al.* in their study with adults were actual size which may have aided the subjects in their estimation of portion sizes. The food models used in the study reported in this chapter were developed for use with young children. In contrast the only food photographs available at the time of this study were developed for use with adults and based on adult portion sizes and this may have contributed to the difference in the children's ability to estimate portion size using the two methods.

Children estimated portion size more accurately using the models than the photographs for 9 out of the 16 foods included in the portion size interview (Approach 3). For 7 of these foods the difference was significant. Over all foods portion size estimates were 147% of the actual weight of the food on average using the photographs and 125% using the food models. Portion size estimations made using models during the food diary interviews (Approach 1) were also closer to the actual weight of the food (118% compared with 131% for the photographs). However for the school dinner diaries (Approach 2) the children were more accurate in estimating portion size using the food photographs (149% compared with 177% for the models).

From the portion size interviews 46% of children's estimates using the food models were correct to within 30% of the actual portion size and 43% of children's estimates using the food photographs were within 30% of the actual portion size. This level of precision is approaching that of adult estimates using food photographs which were within 30% of the actual weight of the food 55% of the time (Nelson, Atkinson et al. 1996).

The errors in portion size estimation were relatively high using both portion size assessment tools, even at the group level. It is possible that, despite the error, the use of these tools may still result in a more representative picture of habitual dietary intake compared with weighed food diaries. The lower respondent burden should mean more people are prepared to keep a record of their child's food intake and diet is less likely to be changed due to the burden of weighing foods.

It may be that by using a combination of different portion size assessment tools, accuracy can be improved. Some food morphologies may lend themselves to presentation in photographs whereas for others three-dimensional models may be more appropriate. It is difficult to draw conclusions from the current study as to which food morphologies are best estimated using the food models and which are best estimated using the food photographs as the results are conflicting. For liquid foods milk was estimated most accurately using the food photographs whereas squash was estimated most accurately using the food models. For semi-solid foods ice-cream was estimated most accurately using the food photographs and mashed potato using the food models. Further research into the best way to represent both individual foods and particular morphologies of foods is required in order to minimise the error associated with portion size estimation.

The limits of agreement were narrower for the portion size perception interview than for either the school dinner data or the food diary data. This may be due to the increased variance introduced due to parents errors in weighing the children's food for the food diary and the use of average serving weights for the school dinner diaries.

5.9.2 Gender differences

Females estimated portion size more accurately than males for 10 of the 16 foods included in the portion size interview but none of these differences was significant (p>0.05). Over all foods the mean estimates for boys and girls were similar averaging 138% of the actual weight of the food for males and 135% for girls for the portion size interviews. Girls also performed better than boys in portion size estimations for both the food diary data (122% of the actual weight of the food compared with 129% for boys) and the school dinner data (133% of the actual weight of the food compared with 191%). Nelson *et al.* (1996) also found significant gender differences in ability to estimate portion size using food photographs and again males were found to overestimate portion size to a greater degree than did females

5.9.3 Age differences

Across all three approaches the older children performed better than the younger children in their ability to estimate portion size. The older children estimated portion size more accurately than the younger children for 12 of the 16 foods included in the portion size interview (Approach 3). For 7 of these foods the difference was statistically significant. The foods which were significantly more accurately estimated by the older children were mainly liquid or amorphous foods and this may be indicative of a conceptual difficulty for the younger children in estimating the size of these foods (Shaffer 1999). Over all foods the younger children on average estimated food portion size to be 148% of its actual size compared with the older children who on average estimated portion size to be 128% of actual size. During both the food diary interviews (Approach 1) and the school dinner interviews (Approach 2) the older children were significantly more accurate in their estimations of portion size than the younger children. For the food diary interviews the mean portion size estimates of the older children were 110% of the actual weight of the food compared with 135% for the younger children for both tools combined. This difference was highly significant (P=0.006). For the school dinner diary interviews the mean portion size estimates of the older children were 123% of the actual weight of the food compared with 216% for the younger children (p=0.015). As might be expected ability to estimate portion size using both the food models and the food photographs appears to increase significantly with age. For the year 1 (5 to 6 year olds) children 38% of portion size estimates were within 30% of the actual weight of the food, the year 6 children (10 to 11 year olds) were approaching the accuracy of adults with 46% of portion size estimates being within 30% of the actual weight of the food compared with 55% for adults. A number of the cognitive processes required to accurately estimate portion size develop at around the age 10-11 years old. As Piaget suggests there is a great deal of variation in the age at which children enter or emerge from a particular stage of cognitive development (Shaffer 1999) it is likely that the results are highly affected by some children having already developed those particular skills quite well and others hardly at all.

Children completing the food diary and school dinner diaries consumed different foods and the types of foods consumed differed with age. Additionally the reference weights used were prone to error (due to parents weighing the foods for the food diary and the use of average serving sizes for the school dinner diaries). It is sensible, therefore, to rely on the data collected during the portion size interview to look at the differences in performance between the tools with age.

There was a trend for the food models to perform better with the younger children with 7 of the 16 foods being significantly more accurately estimated using this tool. Only 2 foods were significantly more accurately estimated using the food photographs. For the older children estimates of portion size using the food photographs were significantly more accurate for 4 of the 16 foods. Whilst 4 foods were significantly more accurately estimated using the food models.

The food models are three dimensional and life size and as such may be more suited than the food photographs to the cognitive abilities of the younger children. For certain foods however where the presentation of the task with the food models requires cognitive skills such as conservation and reversibility the food photographs performed better. For example to estimate baked beans using the food models the child is asked to estimate the amount of the food in terms of numbers of spoonfuls, an very complex cognitive task. To estimate the amount of baked beans using the food photographs the child has to select from a series of photographs of increasing portion sizes. Both age groups performed better using the food photographs at this task. For younger children a series of three dimensional models along with photographs of foods which are difficult to represent (or estimate) using models may be required.

5.9.4 Comparison of children's estimates of portion size with adults' estimates of portion size

Children's estimates of portion size were compared with adults' estimates of portion size for the same foods from a separate study (Nelson, Atkinson et al. 1994; Nelson, Atkinson et al. 1996) which used the same food photographs (MAFF 1997). Children were found to overestimate portion sizes significantly compared with adults but this tendency toward overestimation was reduced in the older children. The portion sizes of foods presented to the children during the portion size interview were based on children's portion sizes collected during the fruit and vegetable intervention (see Chapter 4). The portion sizes presented in the food photographs were based on adult portion sizes (Gregory and authors 1990). The mean of the portions presented in the food photographs for each food was therefore large in comparison with the mean portion presented in the portion size interviews and this may have contributed to the large overestimation seen with the children estimating portion size using the food photographs. The mean ratio of the portion of food presented to the children and that presented in the photograph was 0.8, the range was from 1.68 for bread to 0.33 for sausages. Bread was the only food for which the mean of the 3 portions presented at the interview (Approach 3) was greater than the mean depicted in the photographs.

The development and use of food photographs specifically designed for use with children and based on children's portion sizes may improve the accuracy with which children can estimate portion size using this tool.

5.9.5 Effect of interview type and number

No significant effect of the two different interview types, 24hr recall or food in front interview, was seen for any food. This was surprising given that memory is stated as one of the major limitations when children are the subjects of dietary surveys (Livingstone, Prentice et al. 1992). Although not significant, for nearly all of the foods estimation of portion size with food in front was more accurate than that by 24hr recall. This would be expected as for the food in front interview there was no effect of memory on the accuracy of the child's estimate. There was no apparent learning effect with a non-significant trend for accuracy of estimates to increase with increasing trials for only three of the foods and a significant learning effect was seen for baked beans only.

5.9.6 Food differences

(Howat, Mohahn et al. 1994) found the portion sizes of solid foods were more accurately estimated than liquid or amorphous foods when adults used food models and food photographs to estimate portion size. No clear results on the effect of the morphology of food on children's ability to estimate portion size emerged from the current study. The most accurately estimated foods using the food photographs were banana, tomato ketchup and apple. Those least accurately estimated were chips, macaroni cheese and sausages. For the food models the foods most accurately estimated were orange squash, tomato ketchup and cake. Those least accurately estimated were chips, cheese and milk. It is interesting that using the food models one of the liquid foods, squash, was the most accurately estimated food with children being only 1% away from the actual weight of the food on average. The other liquid food, milk, on the other hand was very poorly estimated (234% of the actual weight of the milk on average). Only children's estimates for chips were further from the actual weight of the food. The presentation of the two foods in the food models was quite different. The amount of orange squash served was estimated using glasses with lines in equal increments up the side. The amount of milk was estimated using a bowl with equal increments however the child had to imagine the milk in combination with the Rice Krispies. Surprisingly the children were more accurate in estimating the amount of milk using the photographs, where they were asked to indicate where the milk would come up to in a glass even though they had never seen the milk presented in this way.

The portion size of bread was significantly underestimated using both the food models and the food photographs. The bread was presented as a single whole slice of bread on a plate. The photographs depicted a number of different slices of bread on plates and the models included a number of bread shaped slices cut from polystyrene. The largest portion size presented for bread (the 75th centile of intake) was a 'doorstep' slice cut from an un-sliced loaf. It is likely that in reality this was attributable in the main part to children consuming more than one slice of bread but some of the children may have consumed slices of this size and it was therefore included. However all of the options depicted in the photographs and the models weighed less than this slice. The underestimation of the portion size of bread may be attributable to children having picked a slice that was the same in area but not thickness.

The portion size of chips was significantly overestimated both using the food models (237% of actual weight) and the food photographs (185% of actual weight). The chips presented to the children were on a plate with tomato ketchup. The food photographs depicted 8 increasing portions of chips on a plate. For the food models the children could choose from two different chip sizes, French fries or standard chips. They were then asked to place these on an empty plate until the amount of model chips on the plate equalled the amount of real chips on the plate. The reason for the huge overestimation in size is unclear. It may be that in the food photographs the chips were piled more closely together on the plate. Alternatively the chips presented to the children during the interview may have been cooked for longer than the chips presented in the food photographs this would result in a reduction in weight due to water loss but would have little effect on their size. This is a potential problem for all foods which differ in weight but not in size depending on the degree to which they have been cooked.

For the food models the French fries were slightly smaller and the standard chips slightly larger than the real chips presented. Children however opted more frequently for the French fries than the standard chips which should have resulted in an underestimation rather than overestimation of the portion size of the chips. It may be because French fries could be more tightly packed into the same area on the plate. Alternatively, the greater level of interaction required for estimating portion size of this food with the food models may have resulted in the task being too much fun and the child's attention being distracted from the task in hand.

5.9.7 Portion size differences

The children overestimated portion size for 14 of the 16 foods included in the portion size interview. There was a trend for a reduction in the degree of overestimation as the size of the portion increased. This reduction in overestimation is akin to the 'flat slope syndrome' seen in adults. (Lucas, Niravong et al. 1995). Adults tend to underestimate portion size on average, to underestimate the size of large portions and to overestimate the size of small portions (Nelson, Atkinson et al. 1994)a; (Rutishauser 1982). With children, as they significantly overestimate portion size over all, this trend was translated into a reduction in the degree of overestimation.

5.9.8 Effect of the portion sizes presented in the models and photographs on children's ability to estimate portion size

The degree of overestimation seen in this study may be due in part to the use of food photographs designed using adult portion sizes. Children overestimated to a greater extent using the food photographs compared with the food models. The portion sizes of the actual foods presented to the children were based on the portion sizes of foods children ate during the fruit and vegetable intervention study (Chapter 4). The food photographs were based on the range of portion sizes consumed by adults during a national dietary survey, (Gregory and authors 1990) whereas the models were based on those developed for use with children aged 11 to 12 years (Hackett and al. 1984), and used in subsequent studies in 1990 (Adamson, Rugg-Gunn et al. 1992) and 2000 (Fletcher *et al.*, 2001). The models were developed to include a range of sizes and shapes of foods (see section 5.1). The fact that the mean of the portion sizes presented in the photographs was greater than the mean portion of food presented to the children may have resulted in an increased tendency toward overestimation using the food photographs. This reinforces the need for portion sizes presented as an aid to portion size estimation to be appropriate to the subject population. Children overestimated portion size to a greater extent when the largest portion of food actually presented was small in comparison with the largest portion in the range of portions presented for the models or photographs.

The effect of the errors in portion size estimation for these 16 foods on reported nutrient intakes are examined in the following chapter.

Chapter 6 Re-analysis of the fruit and vegetable study

6.1 Introduction

The results of the portion size perception interview (Chapter 5, Approach 3) made it possible to investigate the potential effect of errors in portion size estimation, made using food photographs, on the results of the fruit and vegetable intervention study (Chapter 4). The 16 foods used in the portion size perception interview had been selected to be those most frequently reported as consumed during the fruit and vegetable intervention study which were not easily quantifiable in terms of units or from brand information.

The portion size interview gave an estimate of the error associated with the estimation of portion size for these 16 foods using the food photographs. The ratio of the mean estimated weight to the actual weight was used to adjust the reported weight consumed in the food diary for each of these different foods.

This adjustment analysis was undertaken as a theoretical exercise to investigate the possible impact of errors in portions size estimation on reported nutrient intakes. It is not assumed that applying these adjustments makes the nutrient intake data anymore accurate than the original data.

6.2 Aim

To examine the effect of errors in portion size estimation using food photographs on the apparent nutrient intakes of children participating in the fruit and vegetable intervention study reported in Chapter 4.

To determine to what extent errors due to portion size estimation of 16 of the most frequently consumed foods impacted on the perceived results of the intervention.

6.3 Methods

Prior to adjusting the weights recorded in the food diaries for the 16 foods included in the portion size perception interviews, the proportion of the total foods consumed derived from these foods was calculated both in terms of frequency of consumption and weight consumed. This was done to ensure that these 16 foods made a significant contribution to the total nutrient intake of the group and that adjusting the estimated weights of these foods was a worthwhile endeavour.

The mean error of the children's estimates of food portion size using the food photographs was used to adjust the weights recorded in the food diary. The 16 foods, their percentage error and the adjustment factor are shown in Table 6.1.

Table 6.1 Percentage error and adjustment factor for foods included in the portion size perception interview

Food	Ratio mean estimated:actual wt	Adjustment
Apple	1.16	1/1.16
Banana	1.04	1/1.04
Baked beans	1.30	1/1.30
Cake	1.59	1/1.59
Cheese	1.56	1/1.56
Chips	1.85	1/1.85
Ham	1.34	1/1.34
Ice cream	1.31	1/1.31
Macaroni cheese	1.88	1/1.88
Milk	1.65	1/1.65
Mashed potato	1.74	1/1.74
Orange squash	1.29	1/1.29
Rice Krispies	1.23	1/1.23
Sausages	2.69	1/2.69
Tomato ketchup	1.14	1/1.14
White bread	0.77	1/0.77

Foods to be adjusted were identified by labelling all varieties of the 16 foods included in the portion size perception interview, along with any other foods which are visually the same, by the food name. For example all varieties of sausages (beef, pork etc) were given the label sausage. For the orange squash all types of soft drink were given the label squash. A query within the ACCESS database was then constructed and used to adjust the weights recorded in the food diary using the equation:

Wt of food recorded in the food diary X 1 / Ratio of mean estimated to actual wt

For chips for example the mean estimated weight using the food photographs was 1.85 times the actual weight. The following equation was therefore used:

Weight of chips recorded in the food diary X 1/ 1.85

A factor of 1 was used within the query for all foods not included in the portion size perception interview (Approach 3).

Total nutrient intake, intakes of macronutrients as a percentage of energy intake and fruit and vegetable intakes were then analysed. These data were imported into SPSS where the analyses performed during the fruit and vegetable intervention study were repeated (Section 4.6).

6.4 Results

6.4.1 Proportion of foods to be adjusted

Table 6.2 Frequency and weight of foods for which adjustments could and could not be performed

	No.	Frequency	Weight Kg	%frequency	% food weight
All foods	666	15785	1505.6	100	100
In portion study (Approach 3)	286	6811	973.0	43	65
Package food	120	2826	110.0	18	7
Not in portion study (Approach 3)	260	6148	422.5	39	28

On the 6 days reported by 128 children (768 eating days) 666 different foods were consumed a total of 6811 times (Table 6.2). On 43% of these times foods which were included in the portion size perception interview (Chapter 5) were eaten. Foods included in the portion size interview accounted for 65% of the total weight of food consumed. A further 7% of foods (18% by frequency) were of known weight as they were foods which are presented in pre-determined portions (i.e. Crisps, biscuits etc). Therefore only 28% (or 39% by frequency) of the total weight of food consumed could neither be adjusted, nor verified from package information.

Table 6.3 Contribution of foods to be adjusted to the total nutrient intake

	Total	Included in portion study	% included in portion study
Energy MJ	7539	3026	40
Fat (g)	64194	14687	23
CHO (g)	238119	108260	45
Protein (g)	57020	21635	38
Calcium (mg)	776641	435037	56
Vit C (mg)	81157	56831	70
Iron (mg)	8348	2738	33
β-Carotene (μg)	493648	52349	11
Vitamin E (μg)	6518	2560	39
Retinol equivalents (RE) (μg)	352024	165124	47

Table 6.3 shows that despite the high proportion of the weight of the foods covered by the foods included in the portion size perception interview the contribution these foods made to the nutrient intake varied greatly. The foods included in the portion size perception interview accounted for only 40% of the energy intake, 30% of fat intake, 45% of carbohydrate intake and 38% of protein intake. Values for the other nutrients ranged from 70% for vitamin C to 11% for β-carotene (Table 6.3). These extremes are interesting since we might assume that the same foods (fruit and vegetables) would be sources of each. This is probably due to two foods included in the portion size interview which were consumed very frequently, chips and squash (including fruit juices and sunny delight). These foods contribute large amounts of vitamin C and relatively little β-carotene.

6.4.2 Comparison of original and adjusted fruit and vegetable intakes

Table 6.4 Mean daily intake of fruit and vegetables (g) consumed as measured by 3-day food diaries in intervention (n=64) and control groups (n=65) – Original and adjusted

Variable	T0		T2		Change in intake			Adjusted
	Mean	Adjusted	Mean	Adjusted	Mean	Adjusted	p[2]	p[2]
Fruit wt g[1]								
Intervention	133	123	183	169	+50	+46	0.042	0.052
Control	100	95	107	103	+ 7	+ 8		
Veg wt g[1]								
Intervention	69	63	52	49	-17	-14	0.823	0.925
Control	70	66	55	51	-15	-15		
F&V wt g[1]								
Intervention	202	186	235	218	+33	+32	0.082	0.074
Control	170	160	163	153	- 7	- 7		

[1] The mean daily weights include conversions for fruit juice (dividing by a factor of 2.5) and for vegetable soups to include only vegetable content.
[2] The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups

Adjusting the weight of fruit and vegetables for the error associated with the estimation of portion size using the food photographs resulted in a decrease in the apparent weight of fruit, vegetables and fruit and vegetables consumed for both the intervention and control groups at all time-points (Table 6.4). The increase in the apparent weight of fruit consumed by the intervention group between T0 and T2 was slightly decreased from 50g of 46g. Despite this the increase in the apparent weight of fruit eaten by the intervention group was still significantly greater than the increase in the apparent weight of fruit consumed by the control group (p=0.05), which changed from an increase of 7g to an increase of 8g per day. There was a slight decrease in the apparent reduction of the weight of vegetables consumed by the intervention group from 17g to 14g following adjustment whilst the reduction in the control group remained the same (15g). The difference in the change of apparent vegetable intake, between T0 and T2 between the intervention and control groups remained non-significant. In terms of the total weight of fruit and vegetables apparently consumed there was no change in the difference in intake between T0 and T2 for the control group and a difference of only 1g for the intervention group (Table 6.4).

6.4.3 Comparison of original and adjusted macro-nutrient intakes

For all variables in Table 6.5 adjusting the weight recorded in the food diary according to the errors in portion size estimation of the 16 foods resulted in a decrease in reported energy intake of 11%. Percentage energy derived from fat also reduced and percentage energy from carbohydrate increased in all cases. The percentage of energy derived from protein remained largely unchanged. Apparent intakes of starch and sucrose were reduced by the adjustments for errors in portion size estimation. None of the changes in reported intake due to the adjustments resulted in a significant difference between the intervention and control groups in the change in intake from T0 to T2.

6.4.4 Comparison of original and adjusted micronutrient intakes

Adjustment for the errors in portion size estimation resulted in a decrease in the apparent intakes of each of the micronutrients under investigation. Apparent intakes of calcium and vitamin C fell substantially. Apparent intakes of all micronutrients remained higher in the intervention than the control group following adjustments. None of the changes in reported intake due to the adjustments resulted in a significant difference between the intervention and control groups in the change in intake of micronutrients from T0 to T2 (Table 6.6).

Table 6.5 Mean and adjusted mean daily macronutrient intakes at T0 and T2 as measured by 3-day food diaries in intervention and control groups.

Variable	T0		T2		Intervention effect	
	Mean	Adjusted	Mean	Adjusted	P[1]	P[1] adjusted
Energy intake MJ						
Intervention	7.9	7.1	7.9	7.1	0.327	0.419
Control	8.3	7.3	7.9	7.1		
%Energy fat						
Intervention	35.4	34.3	34.9	33.9	0.929	0.880
Control	36.9	35.9	36.3	35.5		
%Energy carbohydrate						
Intervention	51.3	52.5	51.8	52.7	0.368	0.263
Control	49.8	50.9	51.2	52.2		
% Energy protein						
Intervention	13.1	12.9	13.1	13.2	0.097	0.064
Control	13.0	12.9	12.2	12.2		
Intake of Starch (g)						
Intervention	128	122	131	126	0.980	0.934
Control	131	127	134	127		
Intake of Sucrose (g)						
Intervention	55.1	50	54.6	50	0.578	0.372
Control	56.7	52	52.7	48		

1.The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups from a multiple regression model which included age and sex.

Table 6.6 Mean and adjusted mean daily micronutrient intakes at T0 and T2 as measured by 3-day food diaries in intervention and control groups

Nutrient intake	T0		T2		Intervention effect	
	Mean	Adjusted	Mean	Adjusted	P[1]	P[1] adjusted
Calcium (mg)						
Intervention	900	737	807	667	0.792	0.778
Control	866	714	756	631		
Iron (mg)						
Intervention	9.5	9.0	9.2	8.8	0.644	0.582
Control	8.8	8.2	8.2	7.7		
Vitamin C (mg)						
Intervention	89.5	74.1	98.8	82.2	0.578	0.605
Control	76.4	61.3	79.4	64.5		
β-Carotene (μg)						
Intervention	519	513	536	560	0.774	0.794
Control	529	491	494	488		

1.The value shown is the significance of the difference in change in intake from T0 to T2 between the intervention and control groups from a multiple regression model which included age and sex.

6.4.5 Validity of the food diary with photographs method – comparison of original and adjusted data with a nationally representative sample

The adjusted intakes were compared with intakes reported by 4 to 6 year olds completing a national dietary survey (Gregory and Lowe, 2000). The national survey was conducted using a 7-day weighed inventory which is itself prone to problems of underreporting and subject selection bias (sections 2.4.), therefore the data from the national sample should not be considered to be correct. Adjusting the nutrient intake data for the errors in portion size estimation using the food photographs resulted in the apparent energy intake of the 5 to 6 year olds falling from 8.0MJ to 7.1MJ, which is closer to the mean energy intake of 6.1MJ reported by the national sample (Gregory and Lowe 2000) although still high in comparison. The energy intakes of the 10 to 11 year olds were adjusted from 8.1MJ to 7.3MJ from slightly above to slightly below the mean energy intake of 7.7MJ reported by 11 to 14 year olds completing a national dietary survey (Gregory and Lowe 2000). Percentage energy derived from carbohydrate increased from 50.1% to 51.8%, for the 5 to 6 year olds, much closer to the mean of 51.5% reported in the national survey (Gregory and Lowe 2000). Adjusting the data also resulted in percent energy from carbohydrate being closer to the national average reported by the 11 to 14 year olds, increasing from 50.5% to 51.2% compared with a national average of 51.5% (Gregory and Lowe 2000). The percentage energy derived from protein was unchanged in relation to the mean reported by the national sample, however the percentage energy from fat changed from being higher than in the national survey to be lower than that reported in the national survey for both age groups. Only the energy intakes of the youngest children were significantly different from the average for the national survey and this significance remained following the adjustments ($p<0.001$) (Table 6.7).

Table 6.7 A comparison of the original and adjusted mean macronutrient intakes with national averages for each age group

	5 to 6 year olds					10 to 11 year olds				
	NDNS[1] 4-6 yr olds	(mean±sd)	adjusted (mean±sd)	p^2	p^2 adjusted	NDNS 11-14 yr olds	(mean±sd)	adjusted (mean±sd)	p^2	p^2 adjusted
No. of subjects	355	53	53			475	54	54		
Energy MJ	6.1	8.0 (1.52)	7.1 (1.27)	<0.001	**<0.001**	7.7	8.1 (2.04)	7.3 (1.73)	<0.5	<0.5
% Energy Fat	35.8	36.5 (4.15)	35.0 (3.78)	<0.5	<0.5	35.7	36.0 (5.01)	34.3 (4.85)	<0.5	<0.5
% Energy Carbohydrate	51.5	50.1 (4.79)	51.8 (4.17)	<0.1	<0.5	51.5	50.5 (5.37)	51.2 (5.03)	<0.5	<0.5
% Energy Protein	12.8	12.9 (2.11)	12.7 (2.04)	<0.5	<0.5	12.9	13.3 (2.40)	13.3 (2.54)	<0.5	<0.5

1. (Gregory and Lowe 2000)
2. p value given is the significance of the difference between the mean intake and the NDNS value and the adjusted mean intake and the NDNS

Table 6.8 A comparison of the original and adjusted mean micronutrient intakes with national averages for each age group

	5 to 6 year olds					10 to 11 year olds				
	NDNS[1] 4-6 yr olds	(mean±sd)	adjusted (mean±sd)	p[2]	p[2] adjusted	NDNS 11-14 yr olds	(mean±sd)	adjusted (mean±sd)	p[2]	p[2] adjusted
No. of subjects	355	53	53			475	54	54		
Calcium (mg)	681.5	897 (289.3)	729 (204.7)	<0.001	<0.5	720	842 (317.6)	696 (247.2)	<0.01	<0.5
Iron (mg)	7.8	8.5 (1.96)	8.0 (1.92)	<0.05	<0.5	9.8	9.5 (3.59)	8.9 (3.49)	<0.5	<0.1
Retinol (RE) (ug)	499	516 (238.2)	372 (254.0)	<0.5	<0.5	492	496 (323.5)	449 (423.7)	<0.5	<0.1
Vitamin C (mg)	66.1	91.9 (58.9)	74.6 (47.2)	<0.001	<0.5	73.6	74.7 (46.1)	61.4 (37.8)	<0.5	<0.1

1. (Gregory and Lowe 2000)
2. p value given is the significance of the difference between the mean intake and the NDNS value and the adjusted mean intake and the NDNS value

Adjusting the weights of the foods recorded in the diary according to the findings of the Portion Size Perception Interview (Chapter 5) resulted in a reduction in reported intakes of all micronutrients (Table 6.8). Calcium reduced from 897mg to 729mg for the 5 to 6 year olds but was still high in comparison with the national average of 682mg (Gregory and Lowe 2000). For the 10 to 11 year olds the adjustments resulted in calcium intakes being close to the national average. Intakes were reduced from 842mg to 696mg compared with a national average of 720mg (Gregory and Lowe 2000). Iron intakes of the 5 to 6 year olds became closer to the national average of 7.8mg being adjusted from 8.5mg to 8.0mg. The iron intakes of the 10 to 11 year olds however were slightly low in comparison with the national average of 9.8mg (Gregory and Lowe 2000) and were adjusted from 9.5mg to 8.9mg. Retinol intakes were adjusted from above the national average to below the national average. For the 5 to 6 year olds retinol intakes were decreased from 516μg to 372μg compared with a national average of 499μg (Gregory and Lowe 2000). For the 10 to 11 year olds the change in reported retinol intake was much less substantial reducing from 496μg to 449μg compared with a national average of 492μg (Gregory and Lowe 2000). Vitamin C intakes of the 5 to 6 year olds were closer to the national average reducing from 91.9mg to 74.6mg compared with a national average of 66.1mg. Vitamin C intakes of the 10 to 11 year olds reduced from 74.7mg to 61.4mg, low in comparison with the national average of 73.6mg.

Adjustment of the weights of the foods recorded in the food diary resulted in 7 of the apparent intakes of nutrients being closer to the national average as reported in the NDNS survey and 8 being further from the NDNS value. Adjustment resulted in no changes in significance of the difference in reported macronutrient intake in the fruit and vegetable study and that reported in the NDNS study (Gregory and Lowe 2000), with energy intakes of the 5-6 year olds remaining the only significant difference. Adjustment according to the error associated with portion size estimation using the food photographs meant the differences between NDNS data and the food diary data were no longer significant for calcium intake for both age groups and for iron and vitamin C intakes for the younger age group.

6.4.6 Identification of low energy reporters and overreporters

Table 6.9 Number of children classified as under- and overreporters before and after adjustment for portion size assessment errors

Number (%)		5-7 yr olds	9-11 yr olds	Total
Children for whom body weight was available.		41	50	91
Low energy reporters	Unadjusted	6 (15%)	33 (66%)	39 (43%)
	Adjusted	13 (32%)	40 (80%)	53 (58%)
Overreporting	Unadjusted	12 (29%)	7 (14%)	19 (21%)
	Adjusted	14 (33%)	5 (10%)	19 (21%)
Reporting energy intakes within range	Unadjusted	23 (56%)	10 (20%)	33 (36%)
	Adjusted	14 (33%)	5 (10%)	19 (21%)

Cut-off points based on multiples of BMR (Torun *et al.*, 1996) were used to identify low energy reporters and over reporters (section 4.6.4). To allow comparison these were the same exclusion criteria employed in the National Diet and Nutrition Survey (Gregory and Lowe, 2000).

The number of children classified as low energy reporters increased from 43% of the children for whom weight was available to 58%. Levels of low energy reporting increased in the 5 to 7 year olds from 15% to 32% and in the 9 to 11 year olds from 66% to 80%. There was no increase over-all in children suspected of overreporting, but rates of overreporting decreased from 14% to 10% in the older children and increased from 29% to 33% in the younger children. The proportion of children reporting energy intakes within the acceptable range decreased from 36% to 21% (Table 6.9). Energy intakes were deemed to be within the acceptable range if they were between 1.28-1.79 x BMR for 1 to 5 year olds, between 1.39-2.24 x BMR for 6 to 18 year old boys or between 1.30-2.10 x BMR for 6 to 18 year old girls (Torun *et al.,* 1996).

6.5 Discussion

A large proportion of the foods consumed both in terms of frequency of consumption and in terms of total weight of foods consumed were made up of the 16 foods included in the Portion Size Perception Interview. A total of 1586 different foods were reported as consumed during the fruit and vegetable intervention study however the 16 foods from the Portion Size Perception Interview accounted for 43% of the foods consumed by frequency and 65% by total weight. Taking into account the foods of known weight due to package information only 28% of the weight of foods consumed by children completing the food diaries during the fruit and vegetable intervention study (Chapter 4) remained unadjusted. This was considered a sufficient proportion of the total weight to warrant continuing with the adjustment according to the results of the Portion Size Perception Interview.

The adjustments made to the data were based on a sample size of 219 estimates per food made by 108 children. The variability of estimates was wide, with a range of over and underestimates for each food. It would certainly not be advisable to use the mean error in portion size estimation to adjust an individuals' nutrient intake data. At the group level it is reasonable to adjust intake by the mean error and this is evidenced by the fact that the adjusted apparent nutrient intakes are closer to the mean reported intakes (measured using a 7-day weighed inventory) of the nationally representative sample (Gregory and Lowe 2000).

This adjustment analysis was under-taken as a theoretical exercise to investigate the possible effects of errors in portions size estimation on reported nutrient intakes. Extensive research into the nature of errors in portion size estimation is required to determine if and how adjustments due to portion size estimation errors might be made.

Data from a much larger sample would yield age specific and gender specific adjustment factors. Other characteristics such as the subjects' weight, satiety at the time of the interview, liking for the particular food and familiarity with that food may all impact on portion size perception. Taking all of these aspects into account, however, may result in the convenience of the food photograph method being negated.

An increase of the range of foods included in such an adjustment would also be desirable, although the foods included in the Portion Size Perception Interview accounted for a large proportion of the weight of foods consumed this did not translate to all nutrients. The foods included in the Portion Size Perception Interview accounted for only 40% of the total energy intake of the group. Values for other nutrients ranged from 70% for vitamin C, (citrus fruits were not included in the portion study but fruit juices were) to 11% for β-carotene.

6.5.1 Effect of the adjustments on the apparent success of the fruit and vegetable intervention

Of the 16 foods included in the Portion Size Perception Interview three were fruits, apples, bananas and fruit juice and one vegetable, baked beans but these made up 69% of the weight of all fruits and vegetables consumed. In total 205.4kg of fruit and vegetables were consumed by the children taking part in the study. Fruit juice accounted for 67.3kg (33%), apples 36.3kg (18%), bananas for 20.6kg (10%) and baked beans for 15.6kg (8%). The portion size of the fruits and vegetables included in the Portion Size Perception Interview were on average overestimated. Fruit juice (squash in the Portion Size Perception Interview) was estimated to be 114% of its actual weight, apples 118% of their actual weight, bananas 105% of their actual weight and baked beans 139% of their actual weight. This overestimation is reflected in the reduction in the weights of fruit and vegetables recorded as consumed following adjustment for the errors in portion size estimation.

Adjusting the weights of foods recorded in the food diary resulted in a decrease in the reported weight of fruit, vegetables and fruit and vegetables for all groups and at all time-points. The increase in intake of fruit from T0 to T2 in the intervention group remained significantly greater than the increase in the control group. The difference in the change in vegetable intake from T0 to T2 between the intervention and control groups remained non-significant. There was no change in the difference in intake of fruit and vegetables together between the intervention and control groups. The main results of the intervention study were not altered by adjustment of the weights recorded in the food diary according to the errors in portion size estimation.

6.5.2 Effect of the adjustments on reported nutrient intakes

In all cases adjusting the nutrient intake data for the errors in portion size estimation resulted in a decrease in energy intake. This would be expected as all foods except for bread were overestimated. The reduction in percentage energy derived from fat and increase in percentage energy derived from carbohydrate is likely to be due to the children grossly overestimating the portion size of several high fat foods including chips which were estimated to be 185% and sausages which were estimated to be 269% of their actual portion size on average. This would be augmented by the children's underestimation of the portion size of bread which was estimated to be 77% of its actual weight on average. The reduction in starch intake is likely to be due to the children's overestimation of the portion size of chips (185%), mashed potatoes (174%) and Rice Krispies (123%) but this would be offset by the underestimation of the portion size of bread (77%). The reduction in sucrose intake is likely to be due to the children's overestimation of the portion size of cake (159%), Coco Pops and Ricicles (123%) (included in the category of Rice Krispies) and fizzy drinks (129%) (included in the category of squash).

The decrease in reported calcium intakes following adjustment is due to the children's overestimation of the portion sizes of both milk (165%) and cheese (156%). The fall in vitamin C intakes is likely to be due in the most part to the children's gross overestimation of the portion size of chips (185%) and overestimation of fruit juice (129%). The slightly larger drop in the reported β -carotene intakes in the control group may be due to overestimation of juice (129%), a small number of children in the control group drank carrot juice and mango juice both very high in β –carotene.

The reported β-carotene intakes can be taken as a rough estimate only of the actual nutrient intakes due to the incompleteness of the food composition data for this nutrient. The foods included in the Portion Size Perception Interview accounted for only a small proportion of the total intake of β-carotene (11%).

6.5.3 Effect of the adjustments on the apparent validity of the food diary with photographs method

Adjusting the nutrient intake data for the errors in portion size estimation using the food photographs resulted in the apparent energy intake and percentage energy derived from carbohydrate being closer to that reported in the National Diet and Nutrition Survey (Gregory and Lowe 2000) by the relevant age group. The percentage energy derived from protein was unchanged in relation to the national average but the percentage energy from fat changed from being higher than the national average to be lower than the national average. Only the energy intakes of the youngest children were significantly different from the national average and this significance remained following the adjustments.

Adjusting the weights of the foods recorded in the diary according to the findings of the portion size perception interview resulted in the apparent values for calcium being closer to the national average for both age groups and the values for iron and vitamin C being closer to the national average for the 5 to 6 year olds. The 10 to 11 year olds intakes' of iron and vitamin C, and retinol intakes for both age groups were low in comparison with the national average following adjustments.

6.5.4 Effect of the adjustments on the number of children classified as under- and overreporters

Adjusting the weights recorded in the food diary according to the findings of the portion size perception interview resulted in an increase in the number of children considered to be low energy reporters. This would be expected as most of the foods were overestimated and therefore adjustment resulted in a substantial decrease in the reported energy intakes. Interestingly the percentage of children suspected of overreporting their energy intake did not change overall and although it decreased in the 9-11 year olds it was seen to increase in the 5 to 7 year olds. The only food for which portion size was substantially underestimated was bread. Five children not previously classified as overreporters were now classified as such and these children were found to be large bread consumers who consumed relatively few chips and sausages, the two foods most grossly overestimated. By contrast the three children who were no longer classified as overreporters were found to be low bread consumers, one child reported consuming no bread during the full 6 days of recording and another child consumed bread only once. These children were also found to be high consumers of chips, one child consuming chips on all 6 of the recording days and another child on 5 days.

6.5.5 Summary

The effect of the adjustments to the weight recorded in the food diary for the 16 foods in the portion size perception interview resulted in few major changes to the interpretation of the fruit and vegetable intervention study results. There were no changes in the significance of the difference between the changes in fruit intake, vegetable intake or fruit and vegetable intake for the intervention and control groups.

In terms of nutrient intake there was no change in the significance of the difference in change in intake from T0 to T2 between the intervention and control groups. All differences remained statistically non-significant.

Intakes of energy and most nutrients were closer to the national average following adjustments, but there were a greater number of children suspected of underreporting their food intake and fewer subjects reporting energy intakes within the acceptable range of energy intake: energy expenditure. Both before and after adjustments the proportion of children classified as high and low energy reporters was higher in this study than in the national sample. It would appear that attempts to overcome the problems of underreporting by reducing the burden to the subject were unsuccessful. It may be that the burden of weighing foods is not the major contributing factor resulting in underreporting of energy intakes. It may be that underreporting in children is due in the most part to omission of snacks consumed without the parents knowledge and forgotten by the child. Another factor may be the effect of having eaten the food on the ability to estimate portion size. The children completing the portion size interview (see Section 5.7) were merely remembering the portion size of foods they had seen, whereas the children in the fruit and vegetable study (see Chapter 4) were being asked to remember portion sizes of foods they had actually consumed. Data from the food diary (section 5.5) and dinner diary studies (Section 5.6) would suggest this is not the case as children estimated the portion sizes of foods they had consumed and a tendency to overestimate portion size was still seen.

When the portion size adjustments were made, the changes to both the energy and nutrient intakes reported for the children were quite substantial. It appears the use by children of a photograph atlas designed for use with adults and based on adult portions results in relatively large errors in reported nutrient intakes. Perhaps most importantly the fact that errors in portion size estimation differed with type of food would result in the balance of nutrients being different rather than all nutrients being overestimated to the same extent.

Chapter 7 Final summary and recommendations for future research

7.1 Introduction

This thesis examined methods of assessing dietary intake in primary school children, with particular reference to portion size estimation. From a review of the literature (see Chapter 2) it was concluded that few methods of assessing dietary intake exist which are designed specifically for completion by children. In particular a review of the literature revealed no aids to portion size estimation designed specifically with children in mind. Relatively little research has been conducted into the validity of methods of assessing dietary intake with children. Even with adults, where there has been a plethora of research, there is no ideal 'gold standard' for assessing dietary intake. The more accurate methods are often more demanding for the subject and result in poor study participation and completion rates and many subjects altering their diet due to the burden of recording or providing an incomplete record of their intake. The chosen method of dietary assessment will depend on the population under investigation, the purpose of the study, the precision required and the resources available. In general a compromise is reached between accuracy of the data collected and subject compliance.

For this thesis two methods of collecting dietary intake data, from children, were developed, tested, refined and used to evaluate a fruit and vegetable intervention. In addition the validity of two aids to portion size assessment with children (that is food models and food photographs) was examined. The food photographs were developed by Nelson *et al.* (1997) and published by the Ministry of Agriculture Fisheries and Food using adult portion sizes and were designed for use with adults. The food models used were designed by Hackett and used as part of a diet diary with interview method, the validity of which is reported by Hackett (Hackettt, Pearce et al. 1982). Neither of the two tools were validated previously as aids to portion size estimation with children.

7.2 Assessing dietary intake in children

7.2.1 Limitations

When recording the dietary intake of young children, literacy, memory, motivation, cognitive skills and poor knowledge of food preparation are of concern. In collecting dietary information from the children involved in this study a number of techniques were employed to combat these problems. Attempts to overcome low literacy included the incorporation, in both the diary and record, of spaces for drawing foods consumed away from home. Parents were encouraged to assist their child in completing the diaries via a letter home. Motivation was maintained by providing motivational prizes including stickers for remembering to bring the diary to school and completing the interview, and certificates and pens for completing the study. Memory aids included spaces for drawing foods to facilitate recall of what they ate at school when completing the diary with the help of their parents at home, and slips to go home reminding the child to bring their diary to school for the interviews. For the younger children where memory was expected to be a particular problem, interviews were conducted on a daily basis so that the time between consuming the food and estimating portion size was kept to a minimum. Poor knowledge of food preparation skills was addressed by altering the way questions were phrased e.g. "Did your Mum (or Dad) put it in the oven or was it cooked in a pan on top of the cooker?" and questions on texture, colour and packaging of foods. i.e. asking about the colour of the bottle top rather than the type of milk.

7.2.2 Validity of children's dietary reports

During the pilot study (Chapter 3) accuracy of dietary reports was examined by comparing the reported foods consumed at school dinner with a photograph of the child's meal. The 5-6 year old children reported accurately 83% of all foods consumed and 10% of the reported foods were phantom food reports, that is reported but not consumed. For the 10-11 year olds this accuracy increased to 90% of all foods consumed and only 3% of the reported foods were phantom food reports. Over the total days' intake, accuracy is probably slightly lower as child reports of a meal were validated whereas snacks are more likely to be omitted from a record of intake (Gibson 1990). This level of accuracy is still high in comparison with a study by, (Baranowski, Dworkin et al. 1986) who validated reports of a school dinner by children aged 7 to 11 years. They used very similar methods of reporting diet as employed in the pilot study (Chapter 3) and found 83% agreement.

In terms of nutrient intakes the energy intakes reported during the pilot study were low in comparison with Department of Health study for the 10-11 year olds (Health 1989) the data collection for which took place in 1986. This is however in line with the changes in energy intake seen during the 16 year time frame between the two studies. Energy intakes of the 5-6 year old children however were above the EAR (COMA 1991) and higher than the energy intakes of the older children taking part in the study suggesting overreporting of energy intakes may be a problem in this age group. The percentage energy derived from macronutrients reported during the fruit and vegetable intervention study was similar to national averages (Gregory and Lowe 2000). The energy intakes of the older children were not significantly different from but slightly lower than the national averages (Gregory and Lowe 2000). The younger children again reported intakes significantly higher than the national average (Gregory and Lowe 2000) indicating possible overreporting. This may be due to their greater tendency to overestimate the portion sizes of foods consumed compared with their older counterparts (Section 5.9.3). The greater numbers suspected of underreporting in this study compared with the national average must be due either to omitted foods and/or a genuine decrease in intake during the recording period as portion sizes were found to be overestimated on average by children. From this it can be concluded that the 'memory' aid of getting the child to draw a picture of the foods they consumed at school did not appear to overcome the problem of omitting foods. Younger children were slightly more likely to overreport than underreport. This may be due to a combination of the younger children drawing pictures more frequently, whereas the older children might see this as childish and also a greater tendency for younger children to overestimate portion sizes.

7.2.3 Evaluating an intervention

Both the food diary and the food record were successful in detecting changes in fruit and vegetable intakes at the group level. Whilst at the individual level the validity of the food record was poor at the group level there was good agreement between the two methods in terms of frequency of consumption (Section 4.8.1). Baseline frequency and changes seen were similar to other reported fruit and vegetable intervention studies.

One problem in assessing the effectiveness of an intervention study is the fact that it is very difficult to separate the real changes in dietary intake from reporting bias due to raised awareness of the need to consume more fruit and vegetables. This is a problem that will be encountered with any self-reported dietary intake method. One way around this would be to use biomarkers (Section 2.4.2) such as plasma vitamin and mineral levels pre- and post-intervention but this would add greatly to the expense of the study, would drastically reduce the volunteer rate and may have resulted in difficulties gaining ethical approval to conduct such work with children as young as 5 years. Covertly observing a sub-sample of the study population might be a more feasible alternative. In addition the potential sources of fruit and vegetable biomarkers such as saliva, urine, hair and nails should be explored.

7.2.4 Portion size estimation

Children's ability to estimate portion size using food photographs and food models was examined (See Chapter 5). Children estimated the portion size of just over half of the foods more accurately using the food models than the food photographs. It may be that some foods lend themselves better to representation using models and others using photographs. A method using a combination of the two may be the way forward. On average for the food photographs children were out by almost 50% of the portion size of the food, compared with 25% for the food models.

As might be expected children's ability to estimate the portion size of foods increased with age (Sections 5.5 to 5.7). There was a trend for the food models to perform better with the younger children and the food photographs to perform better with the older children. Shaffer (1999) states young children may view a photograph as an exact replica of reality, he gives the example of a child believing an elephant in a photograph to be a miniature elephant. This was evidenced during one interview using the food photographs where the child could not comprehend the explanation that the plate on which the photographs of food were taken was the same size as the example plate, exclaiming ***'but the plate in the photograph is tiny'!*** The foods for which the food photographs performed better with the younger children were milk, chips, bread and baked beans. For three of these foods portion size estimation using the food models was a very complex cognitive task. For the milk the children were presented with a bowl marked with regular increments and were asked to estimate the amount of a milk from a mixture of Rice krispies and milk. They performed only slightly better with the food photographs where they were asked to estimate the amount of milk by indicating where the milk would come up to if it were in a glass. For the chips the children were asked to manually pile chips onto a plate until they thought the amount was as same as the amount on the test plate and this may have proved too distracting. Finally for the baked beans the children were shown a ladle and were asked to estimate the number of spoonfuls of baked beans that were on the plate. This emphasises the need for portion size assessment tools to appropriate for the stage of cognitive development of the child. The young children's estimates of portion size were most accurate when the task was simply to select a three dimensional shape of the right size from a range of shapes.

There was a slight trend towards overestimation in both age groups both from the validation conducted during the fruit and vegetable intervention study (Chapter 4) and the main Portion Size Perception Interview (Chapter 5). Of children's estimates using the food models 46% were correct to within 30% of the actual weight of the food whilst 43% of children's estimates using the food photographs were within 30% of the actual weight of the food. These are only slightly less accurate than adult estimates using the food photographs which were within 30% of the actual weight of the food 55% of the time. It may be that developing food photographs where the portion sizes presented are based on child portions would result in accuracy being comparable of that with adults. As would be expected, ability to estimate portion size improved with age (Section 5.9.3).

The morphology of food had an impact on portion size estimation. More research is required to better identify the types of food which are most and least accurately estimated. In addition the best way in which to present each food in the portion size assessment aid needs to be determined. This should represent the way in which the food is most commonly consumed and should include factors such as angle of the food photograph. For young children the angle at which food will be viewed on a plate will be smaller compared with adults because of their smaller stature.

The effect of the size of the portion of food presented to the child appears to be the same as with adults with small portions being overestimated to a greater extent than large portions. This may represent a tendency for subjects not to select extreme portion sizes.

The finding that children overestimated portion size to a greater extent when the range of food portion sizes presented was at the lower end of the range of photographs or models available emphasises the need for the range of portions presented in a portion size assessment aid to be appropriate to the target population.

The effect of the error in portion size estimation on reported nutrient intake was examined. The estimated weights recorded in the food diaries during the fruit and vegetable intervention study (Chapter 4) were adjusted according to the mean error in portion size estimation from the Portion Size Perception Interview (Chapter 5). In terms of nutrient intakes the effect of errors in portion size estimation were quite substantial; energy intake was reduced by 11% on average following adjustment for the errors in portion size estimation. This reduction in energy intake resulted in a substantial increase in the proportion of children being classified as low energy reporters (from 43% to 58%). The fact that errors in portion size estimation differed with type of food would result in the balance of nutrients being different rather than all nutrients being underestimated to the same extent. The gross overestimation of the portion size of chips and sausages and underestimation of bread resulted in a higher percentage energy from fat and lower percentage energy from carbohydrate than was likely to have been consumed. Despite the increase in the percentage energy derived from carbohydrate following adjustments it is reassuring, given that all foods other than bread were overestimated that intakes of all nutrients other than carbohydrate were reduced.

The adjustments had little effect on the perceived success of the fruit and vegetable intervention. The main results of the intervention study were not altered by adjustment of the weights recorded in the food diary according to the errors in portion size estimation.

7.3 Implications for assessment of children's diets and suggestions for further research

A number of important issues for future research both in assessing dietary intake and in developing and evaluating dietary assessment tools have emerged as a result of these studies.

The food record although successful in detecting a change in fruit and vegetable intake (Chapter 4) was valid only at the group level. Although the inclusion of only a few categories of food was intended to make the method simpler to complete, in fact this led to confusion, not only of the children involved in this study but also their parents. Using a food diary without an interview or portion size estimation would get around this problem and the burden of categorising foods could be shifted from the subject to the researcher. In addition to reducing the subject burden the accuracy of the data recorded may be improved as errors due to incorrect categorisation would be minimised.

The 3-day estimated food diary method employed in this study resulted in problems with underestimation as has previously been reported with the 7-day weighed food diary method (Section 2.4.3 and 2.4.4). It was hoped that removing the requirement for children or parents to weigh all foods consumed, along with the spaces for the child to draw foods consumed away from home, would result in improved accuracy of reporting of foods consumed. The greater degree of underreporting with the 3-day food diary compared with previous reports of under reporting using 7-day weighed food intake coupled with children's tendency to overestimate portion size suggests that omission of foods is a real problem. When conducting weighed intakes with young children it is necessary to arrange for an adult to record and weigh the foods the child consumes at school. One of the benefits of the estimated diary is that such adult supervision is not necessary, but the method relies much more heavily on the child's memory and this seems to have resulted in an increased number of foods being omitted from the diary, evidenced by increased levels of underreporting.

In assessing the dietary intakes of children an ideal situation would be an observer that followed the child throughout their day and covertly weighed and accurately recorded foods and leftovers for each child. This is impracticable. Further work is required to develop ways of recording dietary intake in children which move towards that ideal with minimum perturbation of the habitual dietary behaviour of the child. Methods should not rely heavily on the child's memory, literacy or motivation and should not be prohibitively expensive.

The use of new technologies such as:

- Disposable cameras
- Video-recording choices at school meals
- Psion or other hand held computers for lay reporters to record school dinner choices
- Digital cameras to photograph each child's meal along with a reference portion of each food for which the weight is known to enable estimation of the portion size of foods consumed.

More research into the causes of underreporting is required both with children and adults. Until the mechanisms behind peoples reasons and motivations to underreport their intake are better understood, self-reported food intake can be viewed only as an estimate of habitual intake.

In terms of portion size estimation, tools specifically for use with children and based on children's portion sizes should be developed and tested. The work initiated by (Gines 1989) in the use of computer technology in aiding portion size assessment should be further investigated. This not only provides an innovative method for assessing and recording portion size but is also likely to capture the attention of even the youngest respondents. It also presents the potential for meal building so the child can estimate the portion size of each food they consumed as part of a meal and see that meal presented on a plate. Not only does this have the benefit of allowing the child to estimate portion size with reference to other foods consumed it may also limit overestimation as overestimation of each of the foods would result in exceeding the plate's capacity.

A research priority should be finding better methods of accurately estimating the portion size of those foods which are the main contributors to energy and nutrients of interest and those foods least accurately estimated. The fact that the 16 foods included in the portion size assessment study accounted for such a large proportion of the foods consumed highlights the consistency of children's diets. Improving the estimation of only 20 to 30 foods could have an important impact on the accuracy of total dietary intake data collected from children.

Further research into the way the representation of foods by the portion size assessment aid affects ability to estimate portion size is required. For example do children perform better when given an open task, that is an infinite number of options rather than a series of pre-determined increments? Does a greater or lesser degree of child interaction with the portion size assessment aid improve the accuracy of estimations?

The aim should be a standardisation, as far as is possible, of the way in which foods are represented and the range of portions presented, whilst recognising that certain foods may need to be represented differently. For example whereas the portion size of amorphous foods can be easily manipulated, foods which tend to be eaten in integral form such as bread or sausages come in predetermined portion sizes. With integral foods the size difference in choosing one integer greater than that consumed may be significant.

By greater quantification and understanding of the errors in portion size assessment it should be possible to make adjustments for the over- or underestimation in portion size which is inherently part of how children behave as well as for the shortcomings of the portion size assessment aid itself.

Given the importance of monitoring diet in children and the low response rate of weighed intakes it is of utmost importance that alternative methods of measuring what children eat are explored. It is important when assessing the validity of any method of measuring dietary intake in young children that we accept the limitations that the subject's cognitive skills impose. Collecting an absolutely accurate record of intake is virtually impossible but by tailoring dietary methods to the specific needs of the population under investigation and by making portion sizes depicted in an aid to portion size estimation representative of the range of portions consumed by that group, the accuracy of children's dietary reports can be greatly improved.

7.4 Future work

Further work is currently under way by a multi-disciplinary team in Newcastle and London to develop and test the validity of three methods of assessing portion size designed for use with children and based on child portion sizes. The three methods are food models, food photographs and a novel computer based portion size assessment tool which explores the potential for meal building. As well as assessing the validity of these tools, the effect of perception, conceptualisation and memory on portion size assessment will be explored. The effects of food morphology and preference on accuracy of portion size estimation will be examined. This work is funded by the Food Standards Agency.

From preliminary analyses both the food photographs and the computer based portion size assessment tool look very promising. The use of photographs based on portion sizes of foods consumed by children resulted in the accuracy of children's estimates of portion size being equivalent to that of adults using the adult food photographs (Foster *et al.*, 2003).

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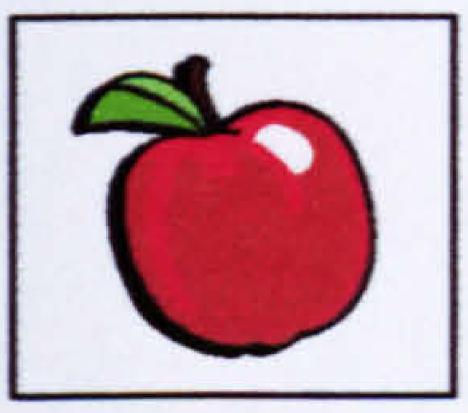
Appendix 1 - Food record used in the Pilot study (Chapter 3)

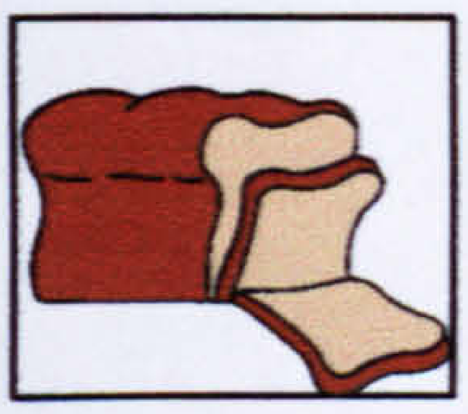
Food record sheet

Please write the name of each item you eat from the four food groups below in the boxes provided including foods not covered by the dictionary. Include tinned fruit and vegetables.

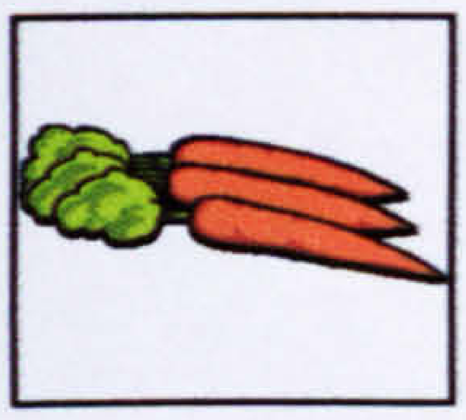
Day 1 - Morning



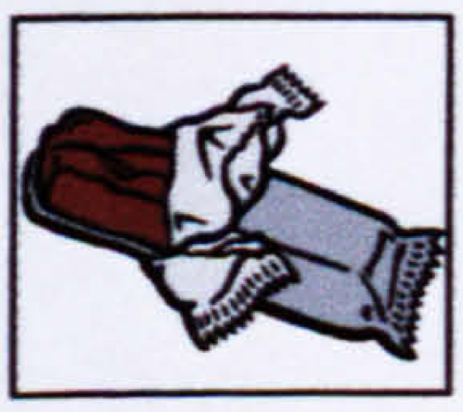
fruit



bread



vegetables



biscuits

Appendix 2 Food picture dictionary used in Pilot study (Chapter 3)

Fruit

 apricot

 apple

 banana

 cherries

 grapefruit

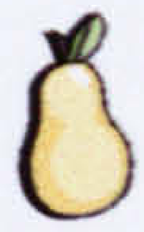
 grapes

 kiwi fruit

 melon

 orange

 peach

 pear

 pineapple

 plum

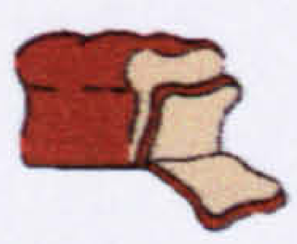
 raspberries

 strawberries

 fruit juice

Bread

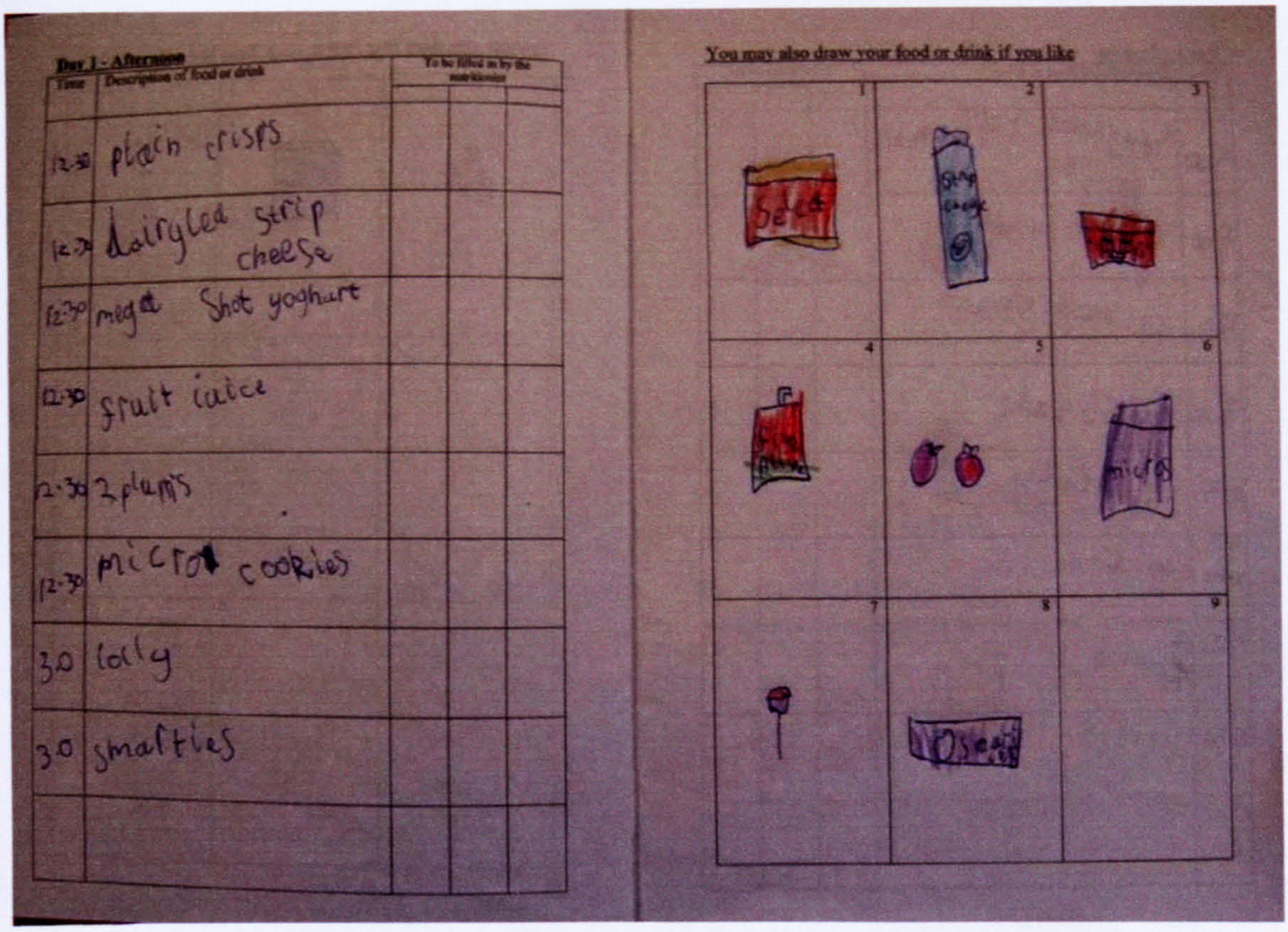
 white bread

 brown bread

 french stick

 bread bun

Appendix 3 – Completed page of Food Diary used in Pilot study (Chapter 3)



Appendix 4 – Food photograph atlas – Example page and in use

Appendix 5 Recruitment Letter sent to the school Headteacher – Pilot study (Chapter 3)

Dear Janet Thomson,

There is increasing evidence that food intake in the early years is important for health in adult life. However measuring food intake in young children is very difficult and because of this many studies avoid using this age group. This is where we need your help. The Human Nutrition Research Centre at the University of Newcastle is conducting a study to develop a method of assessing food intake in primary school children and would like to invite your school to participate. The study is funded by the Ministry of Agriculture Fisheries and Food.

We are looking to recruit at least 30 children in each of two age groups 5-6 year olds and 10-11 year olds from two schools in Newcastle. Some of the children would be required to keep a diary of everything they eat and drink during a three day period, we realise that the younger age group would need assistance from their parents. These children would also be interviewed about their diary to check for missed foods and to try and determine portion sizes. These interviews would last about 15 minutes.

Another group of children would be required to complete fruit and vegetable record sheets, this would involve drawing or writing the names of the fruits and/or vegetables which they consume in a day and ticking a box indicating the amount of that item they ate. We would need to have access to the children at school over a 2 week period, during which time the children will be briefed on the methods of recording and asked to record their food intake for three days. We would need to see some of the children individually for a brief interview about their records. Parental consent would be sought for participation.

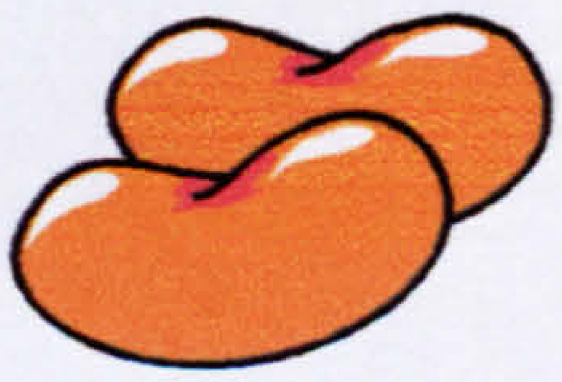
We understand the busy environment of primary schools and would at all times work with you to ensure the minimum inconvenience and disruption. It is our experience that children enjoy recording what they eat. After the study we will make the pooled information on children's food intake available to you and to class teachers for possible use in classroom activities. As a thank you for taking part we will give a book token to the school to the value of 50 pence for each child completing the records.

We will be in contact by telephone over the next few days to give you more information, answer any questions you have about the project and see if you would be interested in becoming involved in the study.

Yours sincerely,

Dr Ashley Adamson
Lecturer.

Emma Foster
Nutritionist - project coordinator



Appendix 6 Recruitment letter sent to parents of children eligible to take part in the Pilot study (Chapter 3)

UNIVERSITY OF NEWCASTLE

Human Nutrition Research Centre
Wellcome Research Laboratories
Royal Victoria Infirmary
Queen Victoria Road
Newcastle upon Tyne NE1 4LP

Newcastle University Food Study

Dear Parent or Guardian of

There is increasing evidence that food intake in the early years is important for health in adult life. However measuring food intake in young children is very difficult and because of this many studies avoid using young children. That's where <u>we need your help</u>. Your child's primary school has been specially selected to help us develop a method of measuring food intake in children. Would you and your child be interested in helping with the study?

We will be conducting the study in Kingston Park Primary school in June of this year and would really appreciate it if you took part.

What would be involved?

We would ask your child to complete a food record sheet for three days. For this we will be looking at only four types of food and would ask your child to write down the name of each food they eat from those categories on a daily record sheet. For the younger children a picture dictionary will be supplied so they can copy the appropriate word onto the sheet.

Some of the children will also be asked to fill in food diaries. This would involve writing down everything they eat and drink for three days, with a little help from yourself. There will be no need to weigh foods. Your child would then be interviewed at school by a trained nutritionist to determine how much they ate of the foods recorded.

How would your child Benefit?

The information from the food diaries and fruit and vegetable record sheets will be given to the school for classroom activities. All information will remain confidential as individuals will not be identified. As a thank-you we will give a book token to the school to the value of fifty pence for each child completing the records.

There is of course no obligation for your child to take part in this project in which case you need do nothing further. If you would like your child to take part please complete the enclosed response form. If you would like more information or have any queries please do not hesitate to contact me on the above number.

Thank you for taking the time to read this.
Yours sincerely,

Emma Foster.
Nutritionist - project coordinator

Direct dial - 0191 222 5276
Switchboard - 0191 222 6000
Fax - 0191 222 5276
e-mail - hnrc@newcastle.ac.uk

Appendix 7 Instructions to parents letter for children taking part in the Pilot study (Chapter 3)

UNIVERSITY OF NEWCASTLE

Newcastle University Food Study

Human Nutrition Research Centre
Wellcome Research Laboratories
Royal Victoria Infirmary
Queen Victoria Road
Newcastle upon Tyne NE1 4LP

Dear Parent or Guardian of

*There is increasing evidence that food intake in the early years is important for health in adult life. However measuring food intake in young children is very difficult and because of this many studies avoid using young children. That's where we need your help. Your child's primary school has been specially selected to help us develop a method of measuring food intake in children. Would you and your child be interested in helping with the study? We will be conducting the study in **** Primary school in June of this year and would really appreciate it if you took part.*

What would be involved?

We would ask your child to complete a food record sheet for three days. For this we will be looking at only four types of food and would ask your child to write down the name of each food they eat from those categories on a daily record sheet. For the younger children a picture dictionary will be supplied so they can copy the appropriate word onto the sheet.

Some of the children will also be asked to fill in food diaries. This would involve writing down everything they eat and drink for three days, with a little help from yourself. There will be no need to weigh foods. Your child would then be interviewed at school by a trained nutritionist to determine how much they ate of the foods recorded.

How would your child Benefit?

The information from the food diaries and fruit and vegetable record sheets will be given to the school for classroom activities. All information will remain confidential as individuals will not be identified. As a thank-you we will give a book token to the school to the value of fifty pence for each child completing the records.

There is of course no obligation for your child to take part in this project in which case you need do nothing further. If you would like your child to take part please complete the enclosed response form.If you would like more information or have any queries please do not hesitate to contact me on the above number.

Thank you for taking the time to read this.
Yours sincerely,

Emma Foster.
Nutritionist - project coordinator

Direct dial - 0191 222 5276
Switchboard 0191 222 6000
Fax 0191 222 5276
e-mail - hnrc@newcastle.ac.uk

Appendix 8 Feedback form used to collect comments on the methods used during the Pilot study (Chapter 3)

<u>Parent comment sheet.</u>

We really appreciate your help with this project and would value your comments on the methods used to measure your child's food intake.

Food record

Did you or your child have any problems filling in the food record? YES / NO

If yes please tell us what problems you had.

Do you have any suggestions for how the food record might be improved?

Food diary

Did you or your child have any problems filling in the food diary? YES / NO

If yes please tell us what problems you had.

Do you have any suggestions for how the food diary might be improved?

If your child were asked to do this again how happy would you be to help again on a scale of 1 to 10 where 1 is very reluctant and 10 is very happy?

very reluctant	1	2	3	4	5	6	7	8	9	10
										very happy

Thank you very much.

Emma Foster and Dr Ashley Adamson.

Appendix 9 Comparison of food diary data with NDNS data

Table A1 A comparison of the macronutrient intakes of children completing the food diaries with data from a national survey[1]

	NDNS 4-6 year olds (mean±sd)	Age 5-6 (mean±sd)	p	NDNS 11-14 year olds (mean±sd)	Age 10-11 (mean±sd)	p
Number	355	19		475	19	
Energy MJ	6.1 (1.21)	7.9 (1.11)	0.001	7.7 (1.70)	7.1 (1.07)	0.5
% Energy Fat	35.8 (4.16)	34.5 (3.9)	0.5	35.7 (4.64)	33.8 (5.0)	0.5
% Energy Carbohydrate	51.5 (4.67)	52.3 (5.3)	0.5	51.5 (4.92)	53.0 (5.4)	0.1
% Energy Protein	12.8 (1.87)	13.3 (2.1)	0.5	12.9 (2.19)	13.1 (2.3)	0.5

1 Gregory *et al* (2000)

As can be seen from Table A1 intakes of energy and macronutrients measured by the food diary for the 10 to 11 year olds did not differ significantly from the national averages (Gregory and Lowe 2000). For the 5 to 6 year olds intakes of macronutrients as a percentage of energy intake did not differ significantly from the national averages but energy intakes were significantly higher (7.9MJ compared with 6.1MJ). This may be due in part to the differences in ages between the two groups but the reported energy intakes of the 5 to 6 year olds were higher than both the national average for the 11 to 14 year olds and the 10 to 11 year olds participating in the pilot study.

Data in the NDNS are presented in age groups 4 to 6 years, 7 to 10 years, 11 to 14 years and 15 to 16 years. As the age groups were not directly comparable with the ages of the children in this study the closest age group was used for comparison. For the younger age group percentage energy from fat was 34.5 compared with the average intake reported by a national sample of 35.8%. Intakes of carbohydrate and protein as a percentage energy were 52.3 and 13.3 respectively, close to the national average for the age group (51.5% and 12.8%).

No significant differences were seen between the energy intakes and dietary composition of the 10 to 11 year olds and the national average (11 to 14 year olds). Percentage energy from fat was 33.8 compared with the national average of 35.7. Intakes of carbohydrate and protein as a percentage energy were 53.0 and 13.1 respectively compared with national averages for the age group of 51.5 and 12.9. Energy intakes of the 10 to 11 year old group were similar to that of the 11 to 14 year old group in the national survey (7.1MJ compared with 7.7MJ).

Table A2 A comparison of the micronutrient intakes of children completing the food diaries with data and a national survey[1]

	NDNS 4-6 year olds (mean±sd)	Age 5-6 yrs (mean±sd)	p	NDNS 11-14 year olds (mean±sd)	Age 10-11 yrs (mean±sd)	p
Number	355	19		475	19	
Calcium (mg)	682 (239.7)	910 (286.0)	0.001	720 (263.3)	695 (185.9)	0.5
Iron (mg)	7.8 (2.29)	8.5 (1.9)	0.5	9.8 (2.93)	7.6 (1.8)	0.01
Retinol (RE) (ug)	499 (236.6)	515 (262.5)	0.5	492 (488.3)	378 (311.5)	0.5
Vitamin C (mg)	66.1 (35.7)	146 (146.8)	0.001	74 (48.8)	99 (78.2)	0.05

1 Gregory and Lowe*l* (2000)

- **Calcuim Intakes**

Mean calcium intakes of the 5 to 6 year olds were higher than the national averages (901mg compared with 682mg). Mean calcium intakes of the 10 to 11 year olds were very similar to the national average (695mg compared with 720mg). This difference was not significant (p=0.5)

- **Iron intakes**

Mean iron intakes of the younger children were slightly higher than the national average (8.5mg compared with 7.8mg) but this difference was not significant (p=0.5). Mean iron intakes of the older children (7.6mg) were significantly lower (p=0.01) than the national average of 9.8mg.

- **Retinol equivalent intakes**

Mean retinol intakes did not differ significantly from the national averages for both age groups (Table 8.2). Mean daily intake for the younger children was 515µg compared with a national average of 499µg. For the older age group intakes were 378µg per day whereas the national mean was 492µg. Neither of these differences was statistically significant (p=0.5).

- **Vitamin C intakes**

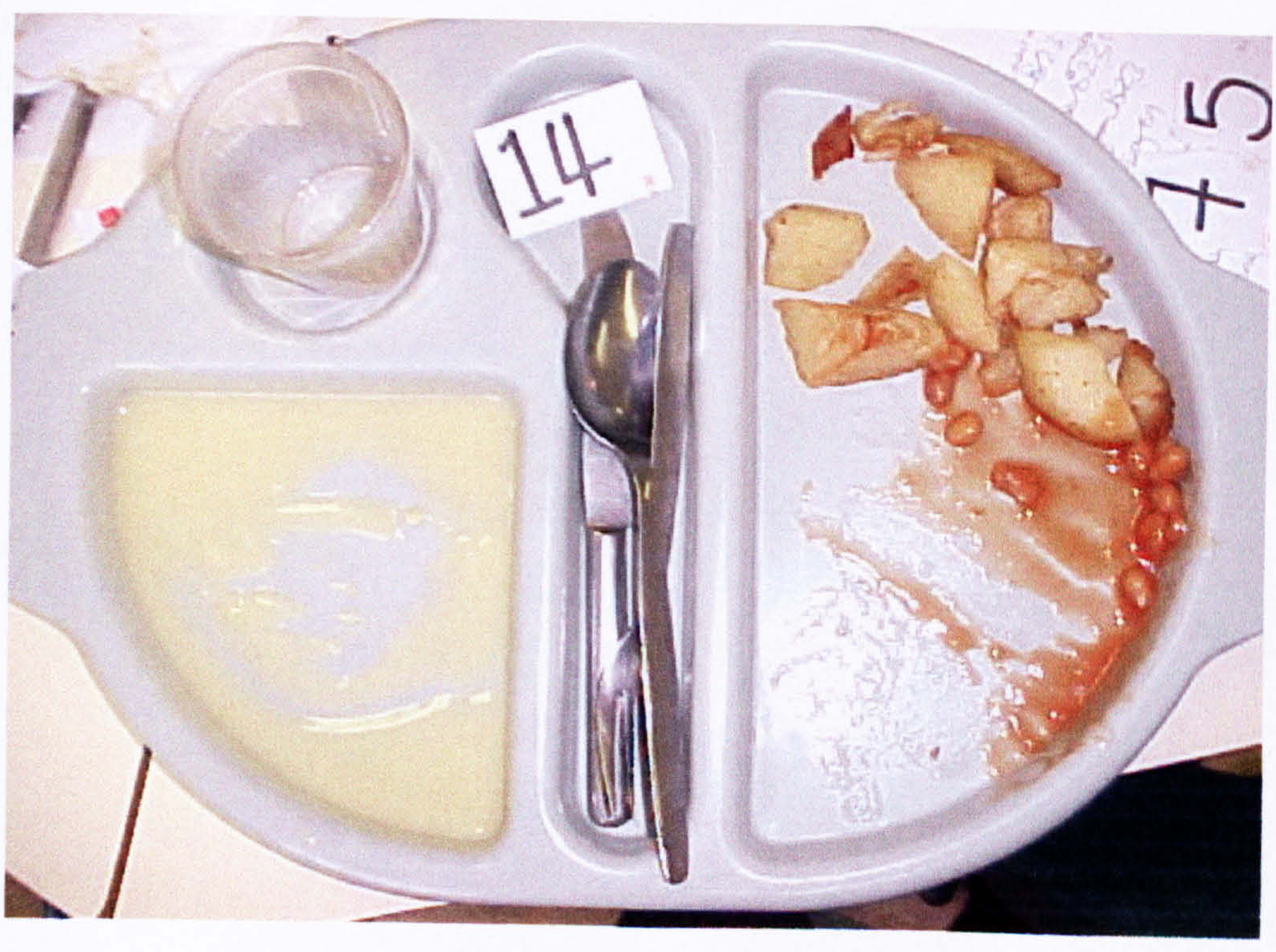
From Table 4.13 it can be seen that mean intakes of vitamin C were significantly higher than the national averages for both age groups. For the younger children mean vitamin C intake was 146mg compared with a national average for this age group of 66mg, this difference was highly significant (p=0.001). For the older children the mean intake was 99mg whereas the national average was 74 mg (p=0.05).

9.1 Conclusions on the comparison of the food diary data with the NDNS data

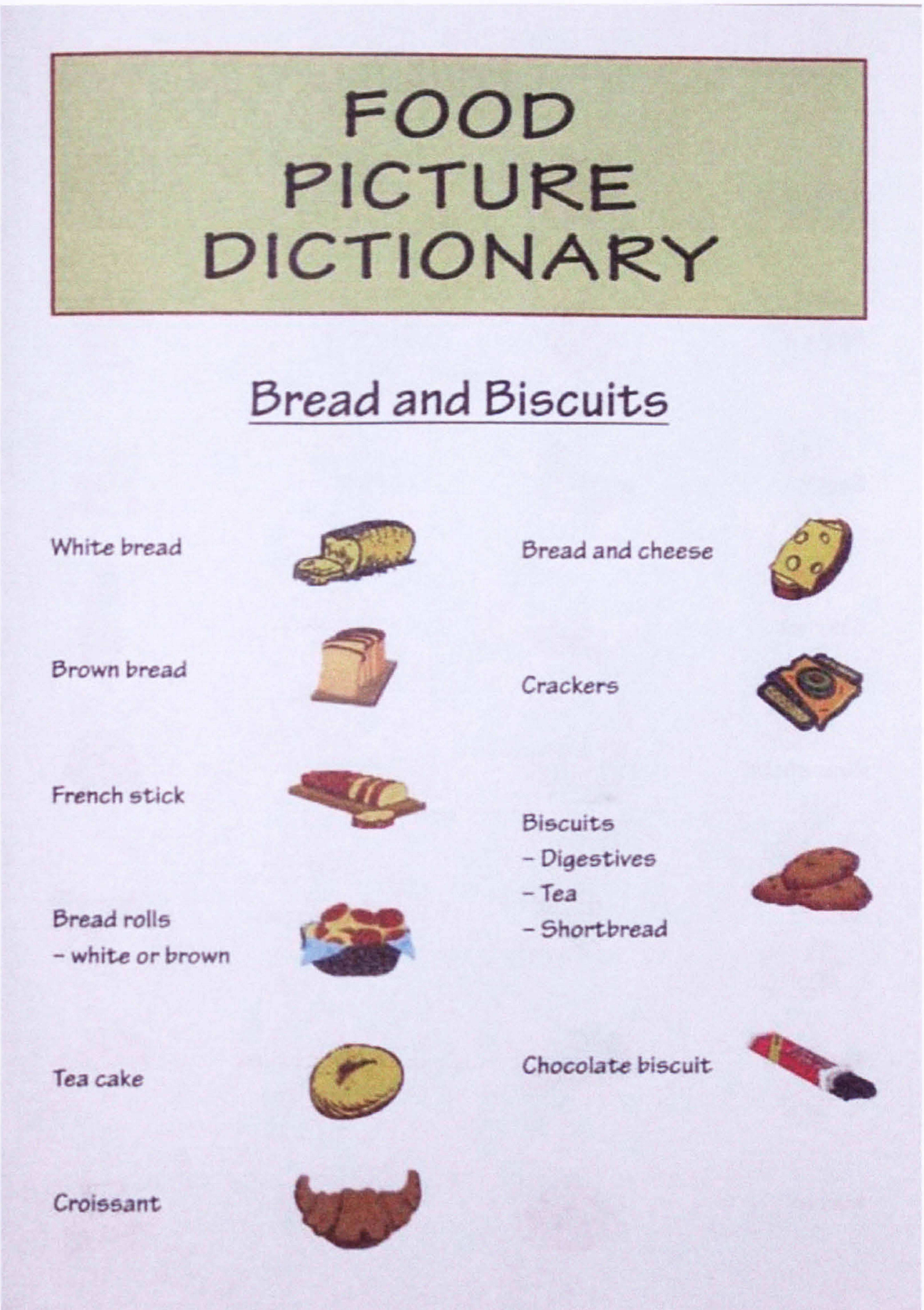
From these comparisons it would seem that the food diary gives a measure of intake comparable with that of a 7-day weighed intake for 10 to 11 year old children. In this age group there were no significant differences in energy or macronutrient intakes. The significant difference seen in micronutrient intakes, namely higher intakes of vitamin C and iron, may be a reflection of the socio-economic status of the subjects taking part in the pilot study. Both of the schools which took part in the pilot study had relatively low free school meal entitlement (Table 3.1), 8% compared with 14% for the NDNS survey (Gregory and Lowe, 2000)

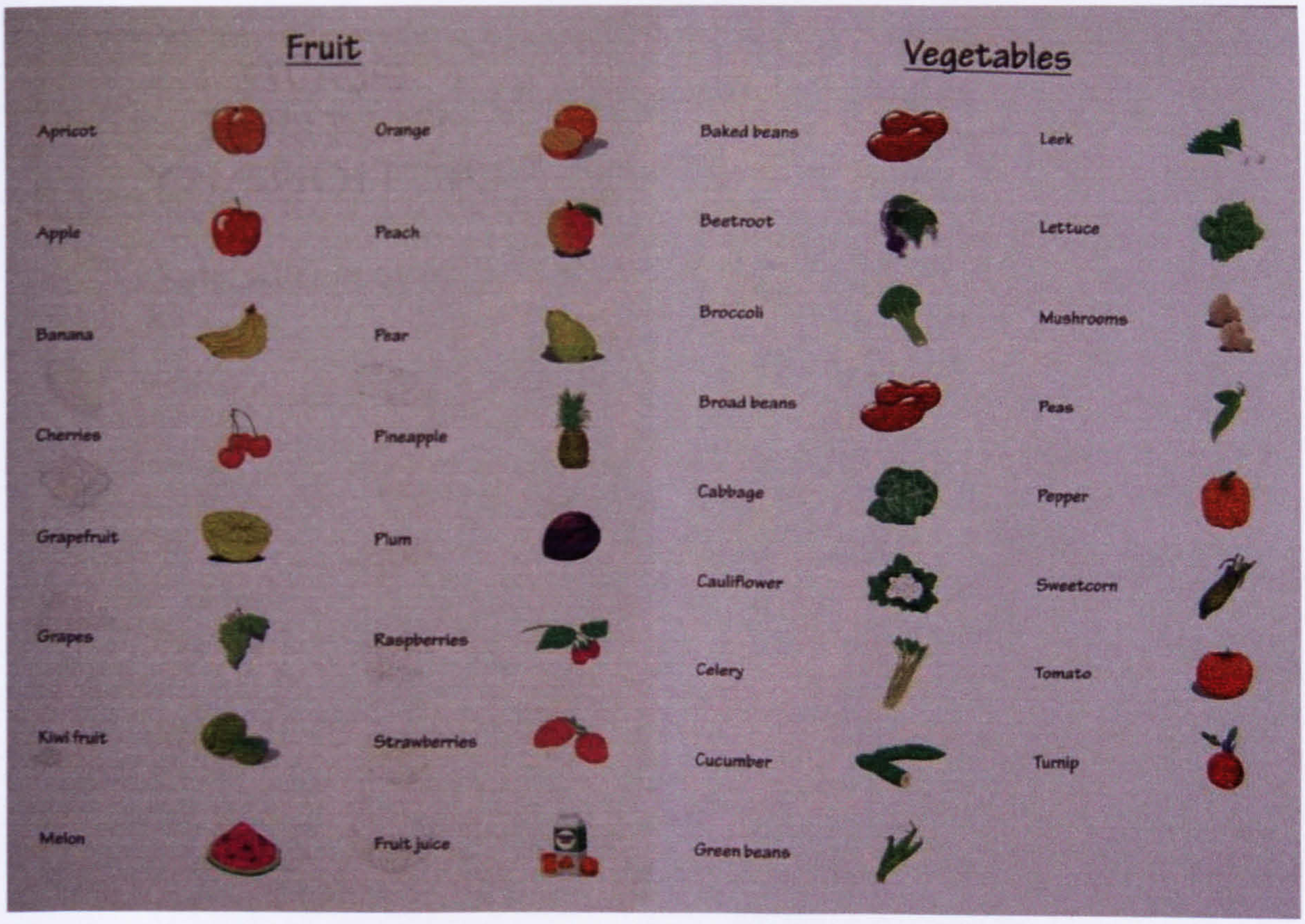
For the 5 to 6 year old age group the significant difference in reported energy intake is cause for concern. The numbers participating in the pilot study are very small however reported energy intakes were higher even than the 10 to 11 year olds participating in the pilot study. It may be that the younger age group made significant overestimates in their assessment of portion size.

Appendix 10 Photograph of School dinner consumed by a subject taking part in the Pilot study (Chapter 3)

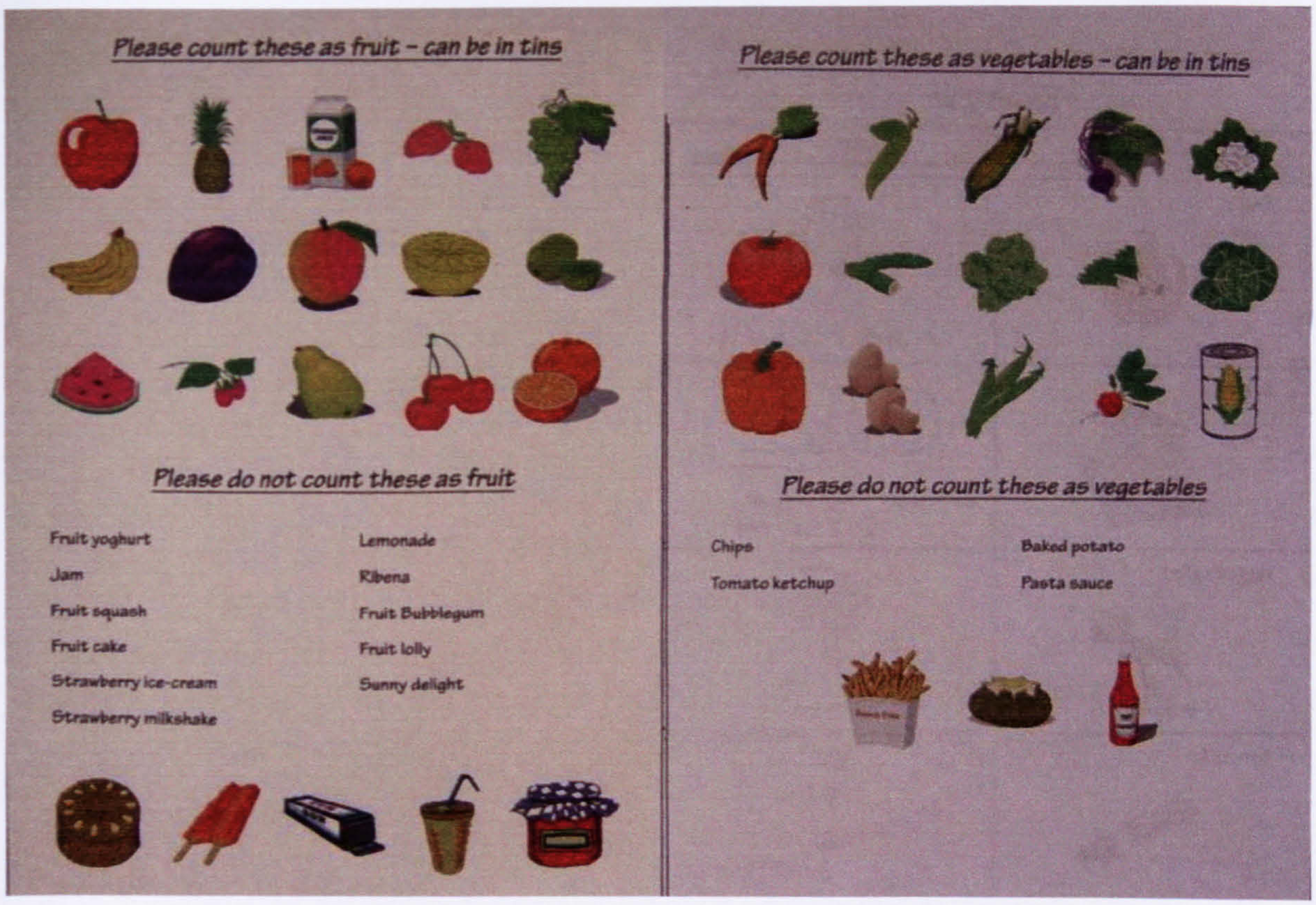


Appendix 11 Revised picture dictionary adapted according to feedback received during the Pilot study (Chapter 3) used in data collection for the Fruit and Vegetable Intervention study (Chapter 4)

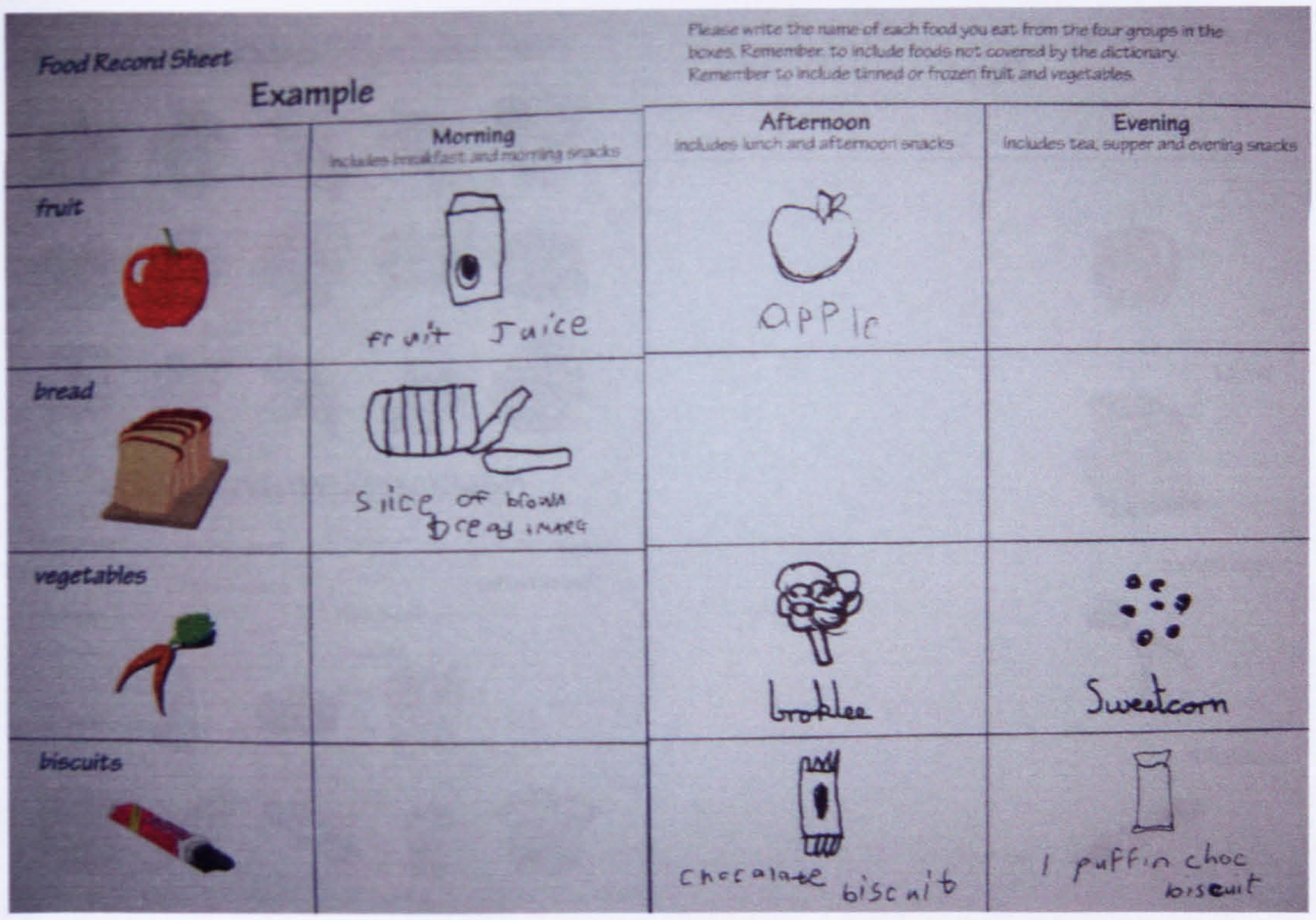



Fruit
Apricot
Apple
Banana
Cherries
Grapefruit
Grapes
Kiwi fruit
Melon
Orange
Peach
Pear
Pineapple
Plum
Raspberries
Strawberries
Fruit juice
Vegetables
Baked beans
Beetroot
Broccoli
Broad beans
Cabbage
Cauliflower
Celery
Cucumber
Green beans
Leek
Lettuce
Mushrooms
Peas
Pepper
Sweetcorn
Tomato
Turnip

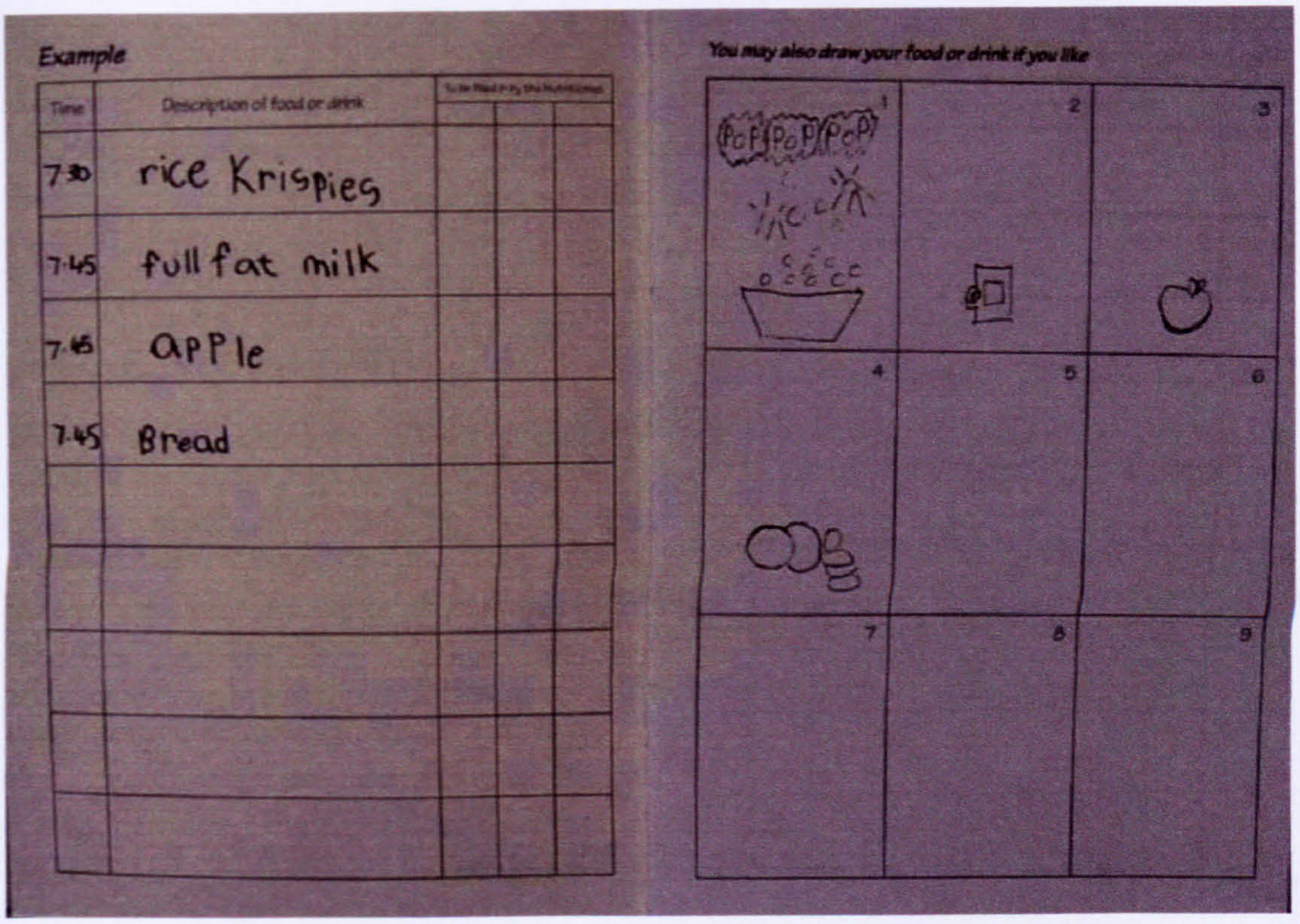
Appendix 12 Examples of foods to include and not to include as fruit and vegetables used in data collection for the Fruit and Vegetable Intervention study (Chapter 4)



Appendix 13 Example of completed food record page – used in Fruit and Vegetable intervention study (Chapter 4)



Appendix 14 Example of completed food diary page – used in Fruit and Vegetable intervention study (Chapter 4)



Appendix 15 Letter used to recruit subjects for the Fruit and Vegetable intervention study (Chapter 4)

Dear Parent or Guardian of ......

Your child's school is one of four schools involved in a study being conducted by the University of Dundee investigating the diets of primary school children in the Tayside area. What children eat is important and as part of the study we would like to collect accurate information on children's food intake. Despite the importance of diet in early life few studies have worked with children of this age because measuring intake in young children is difficult. We have developed methods of measuring food intake specifically for this age group. We would really appreciate it if you would help us with this study by agreeing to your child completing a record of their food intake

What would be involved?

We would ask your child to complete a food record sheet for three days at three times during the following school year. For this we would be looking at only four types of food and would ask your child to write down the name of each food they eat from each of these four categories on a daily record sheet. For the younger children a picture dictionary will be supplied so they can copy the appropriate word onto the sheet.

Some of the children will also be asked to fill in a food diary. This would involve writing down everything they eat and drink for three days and would require a little help from yourself. There will be no need to weigh foods. Your child would then be interviewed at school by a trained nutritionist to determine how much they ate of the foods recorded.

How would my child benefit?

In our experience children enjoy recording their food intake. At the end of the study the information collected would be fed back to the schools for use in classroom activities. This is a study of national importance taking place only in Dundee schools. We hope the children and school will benefit from taking part.

There is of course no obligation for your child to take part in this project in which case you need do nothing further. If you would like your child to take part please complete the enclosed consent form. If you would like more information or have any queries please do not hesitate to contact me on the above number

Thank you for taking the time to read this.

Yours sincerely,
Emma Foster.

Appendix 16 Instructions to parents letter for children completing both the food diary and the food record during the Fruit and vegetable study (Chapter 4)

Dear Parent or Guardian,

Thank you for your agreeing to help with this study. We really appreciate your help.

We would like your child to complete the enclosed diary and record for 3 days starting **Tuesday 30th May**. We realise completing 2 records of intake may seem like giving you extra work but they are designed to measure different things in the diet and it is important to us that both are completed.

For the diary please record all food and drink consumed over the 3 days. Do not worry about weights of foods as your child will be interviewed at school to determine amount of foods eaten.
It is essential, for the interviews, that the children bring the diaries into school with them each day.

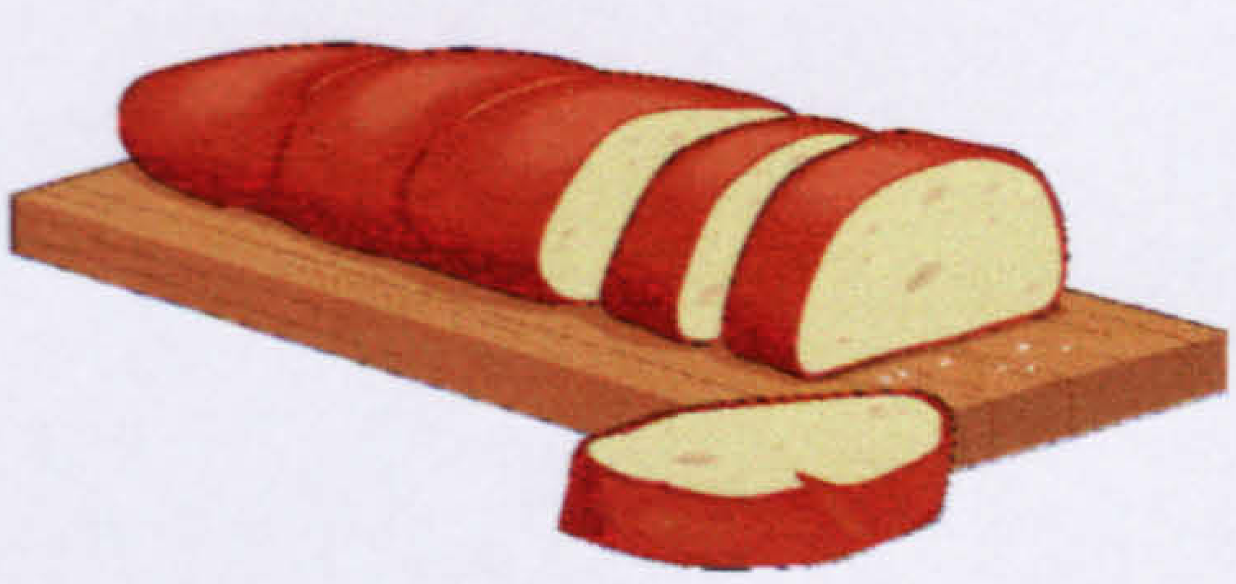
The record is designed to measure only certain foods your child eats, that is bread, biscuits, fruit and vegetables. Do not worry if the record looks empty, this is often the case. Detailed instructions are printed on the back of both the record and the diary if you are unsure of how to fill either of them in.
Feel free to contact me if you have any queries on (01382) 348093.

At the end of the recording period please return the completed diary and record to school.

Finally I would just like to thank you again on behalf of all the staff involved in the study for your all your help, without which the project could not have taken place.
Thank you!!

Yours sincerely,

Emma Foster. Nutritionist.



Appendix 17 Timetable for diet interviewer training

Diet Interviewer Training – 'Lesson plan'

10.00 Diet Interviewer introductions

Information about the schools

Brief theory of the various dietary methods

COFFEE

10.30 Discussion of problems encountered by the interviewers in completing their food diaries.

Discussion of the additional problems encountered with children
Including -Literacy, memory, concentration, awareness of the foods they are eating and methods of cooking.

10.45 Practice interviews Each person interviewed about day 1. Others observe.

11.30 Discussion about the interview, any problems or suggestions for improvement.

Discuss the nature of the questions which should be asked.

Check covered:

i. Probing not prompting

ii. Asking about brands used.

iii. If kids are unsure of foods eaten try for a description eg. If the children are not sure of the type of milk they have ask for the colour of the bottle top or carton

iv. The young children are likely to be unsure of cooking methods but may be able to answer questions such as did your Mum/ Dad cook them in water in a pan or put them in the oven?

v. Do not react to either healthy or unhealthy choices. Avoid giving advice.

12.00 LUNCH

13.00 Using the food atlas.

13.30 Practice interviews using the food atlas — Each person interviewed about day 1. others observe

14.0 Discussion around the use of the food atlas in the interview.

14.30 Final feedback.

14.45 Summary of the main points covered.

Additional problems with children as subjects doing food diaries

The nature of the questions which need to be asked.

Use of the food atlas

15.0 Take home food atlas and one pilot diary each to study.

Day 2

10.0 Questions relating to the food atlas

10.30 Interviews using the child's diary from the pilot and discussion around interviews.

13.00 LUNCH

14.0 Weights of common foods

Including teaspoons of sugar, packet of crisps, common biscuits, small, medium and large apple etc. (produce a list to take home)

Details of how to relay information from the child

14.30 Summary of all the points covered

Any questions or uncertainties about questions to ask or use of the food atlas?

Summary of use of common weights.

14.45 Practical aspects

Meeting – either at the school at the beginning of the school day
OR - At University if they require a lift.

Show the interviewer work record and explain how to fill in.

Appendix 18 Results of children completing food diaries and food records compared with children completing food records alone.

Table A3 Mean fruit and vegetable frequency recorded by food record – Comparison of children completing food records alone with those completing food records and food diaries

		Food records only			Food records and food diaries		
		N	Mean	SD	N	Mean	SD
T0	Fruit	44	1.49	0.779	76	1.12	0.855
	Vegetables	44	1.31	1.147	76	1.10	0.946
	Fruit and Vegetables	44	2.80	1.554	76	2.22	1.475
T2	Fruit	44	1.45	0.674	76	1.38	1.100
	Vegetable	44	1.28	0.980	76	0.91	0.890
	Fruit and Vegetables	44	2.73	1.334	76	2.29	1.682

Appendix 19 Food models used in examining the validity of methods for assessing food portion size with children (Chapter 5)

Appendix 20 Letter to recruit schools to participate in the Food Diary study (Approach 1) Chapter 5

Dear Judy Evans,

Approximately two years ago you were kind enough to allow me to conduct a study to develop methods of recording the dietary intake of primary school children. We are currently conducting a further study looking at children's ability to estimate the size of portions that they consume. We would be most grateful if you would consider helping us again.

There is increasing evidence that food intake in the early years is important for health in adult life. However measuring food intake in young children is very difficult and because of this many studies avoid using this age group. We are looking to recruit at least 50 children who have school dinners from schools in Newcastle. The children would be required to keep a diary (written or pictorial) of everything they eat and drink for school dinners on two occasions, we realise that the younger age group would need some assistance from their parents. The children would then be interviewed the following day to check for missed foods and to try and determine portion sizes. These interviews would last about 5 minutes. We would also like to weigh the average portion of each food served by the canteen staff to enable us to compare this with the child's reported portion size. All interviews would be conducted in school by project nutritionist Emma Foster.

In addition we will be asking for parents who are willing to weigh the foods their child consumes at home and to help their child complete a physical activity diary.

From previous research in schools we do understand the busy environment of primary schools and would at all times work with you to ensure the minimum inconvenience and disruption. It is our experience that children enjoy recording what they eat. After the study we will make the pooled information available to you and to class teachers for possible use in classroom activities. As a thank you for taking part we will give a book token to the school to the value of 50 pence for each child completing the records.

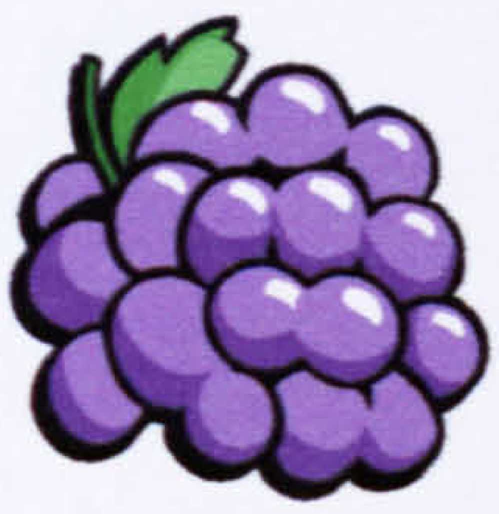
We will be in contact by telephone over the next few days to give you more information, answer any questions you have about the project and perhaps arrange to meet with you to see if you would be interested in becoming involved in the study.

Yours sincerely,

Dr Ashley Adamson
Lecturer.

Emma Foster
Nutritionist - project coordinator

Letter to recruit schools to participate in the School Dinner Diary study (Approach 2) Chapter 5



Dear Mrs Dickinson,

There is increasing evidence that food intake in the early years is important for health in adult life. However measuring food intake in young children is very difficult and because of this many studies avoid using this age group. This is where we need your help. The Human Nutrition Research Centre at the University of Newcastle is conducting a study to develop methods of assessing food intake in primary school children and would like to invite your school to participate.

We are looking to recruit at least 50 children who have school dinners from schools in Newcastle. The children would be required to keep a diary (written or pictorial) of everything they eat and drink for school dinners on two occasions, we realise that the younger age group would need some assistance from their parents. The children would then be interviewed the following day to check for missed foods and to try and determine portion sizes. These interviews would last about 5 minutes. We would also like to weigh the average portion of each food served by the canteen staff to enable us to compare this with the child's reported portion size. All interviews would be conducted in school by project nutritionist Emma Foster.

In addition we will be asking for parents who are willing to weigh the foods their child consumes at home and to help their child complete a physical activity diary.

From previous research in schools we do understand the busy environment of primary schools and would at all times work with you to ensure the minimum inconvenience and disruption. It is our experience that children enjoy recording what they eat. After the study we will make the pooled information available to you and to class teachers for possible use in classroom activities. As a thank you for taking part we will give a book token to the school to the value of 50 pence for each child completing the records.

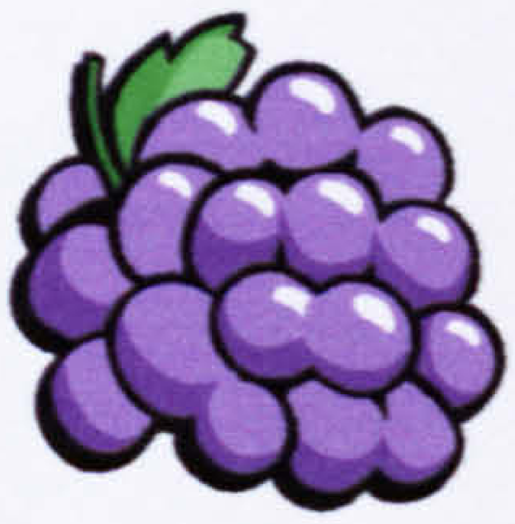
We will be in contact by telephone over the next few days to give you more information, answer any questions you have about the project and perhaps arrange to meet with you to see if you would be interested in becoming involved in the study.

Yours sincerely,

Dr Ashley Adamson
Lecturer.

Emma Foster
Nutritionist - project coordinator

Letter to recruit schools to participate in the Portion Size Perception Interview study (Approach 3) Chapter 5



Dear Bernadette Doherty,

There is increasing evidence that food intake in the early years is important for health in adult life. However measuring food intake in young children is very difficult and because of this many studies avoid using this age group. We would like to see the children for a series of brief interviews during which they would be asked to select a photograph or model of food which corresponds to a portion of food in front of them. We would need to see each child on 6 separate occasions for about 10 minutes. Parental consent would be sought for participation.

From previous research in schools we do understand the busy environment of primary schools and would at all times work with you to ensure the minimum inconvenience and disruption. As a thank you for taking part we will give a book token to the school to the value of 50 pence for each child completing the records.

We will be in contact by telephone over the next few days to give you more information, answer any questions you have about the project and perhaps arrange to meet with you to see if you would be interested in becoming involved in the study.

Yours sincerely,

Dr Ashley Adamson
Lecturer.

Emma Foster
Nutritionist - project coordinator

Appendix 21 School 1 – Recruitment letter to parents for children to complete a food diary (Approach 1) or a School dinner diary (Approach 2)

Newcastle University Food Study

Dear Parent or Guardian.

There is increasing evidence that food intake in the early years is important for health in adult life. However measuring food intake in young children is very difficult and because of this many studies have avoided using young children. That's where <u>we need your help</u>. Your child's primary school has been specially selected to help us develop a method of measuring food intake in children. Would you and your child be interested in helping with the study? We will be conducting the study in your child's Primary School after Easter this year and would really appreciate it if you took part.

What would be involved?

We would ask your child to keep a record of everything they eat or drink at school dinner on two separate occasions. Each child would be given a special recording form in which they may either write the names of the foods they eat or draw a picture if they prefer. They would then be asked to attend a short interview (approx. 10 minutes) with a trained nutritionist. At this interview they will be shown food photographs or food models to determine how much they ate of the foods recorded.

In addition were are looking for parents who would be willing to weigh and record any foods consumed at home and to help their child keep a diary of physical activity. For these children we would also like to measure weight and height.

How will the information be used?

We will use the weights of foods obtained from the catering staff and the parents taking part in the study to compare with the weights of foods selected by children from a series of photographs or models of foods. The information collected will be used to develop methods to accurately measure what primary school children eat. All information will remain confidential as individual children will not be identified, however if we were concerned about your child's diet we would let you know. As a thank-you we will give each child taking part a certificate of achievement and a University of Newcastle pen. The school will also receive a book token to the value of 50 pence for each child who takes part.

There is of course no obligation to take part in this project in which case you need do nothing further. If you would like your child to take part please complete the enclosed consent form and return it to school in the envelope provided as soon as possible.

If you would like more information or have any queries please do not hesitate to contact me on the above number.

Thank you very much for taking the time to read this.

Yours sincerely

Dr Ashley Adamson
Lecturer

Emma Foster
Nutritionist - Project co-ordinator

If you would like more information please call us on 0191 2225276

Appendix 22 School 2 – Recruitment letter to parents for children to take part in the Portion Size Perception Interview (Approach 3)

Newcastle University Food Study

Dear Parent or Guardian.

We need your help!!

What we eat in the early years is important for health in adult life. Measuring food intake in young children is very difficult. Your child's primary school has been specially chosen to help us develop a method of measuring food intake in children. Would you and your child be interested in helping with the study? We will be carrying out the study in Wharrier Street Primary School in May and June of this year and would really like you to take part.

What would be involved?

- We would ask your child to go to four 5-min interviews at school.
- We would show your child different amounts of food.
- We would ask them to choose a photograph or model which looks most like the amount of food in-front of them.

How will the information be used?

This work will help us find out how children see and remember food portion sizes. The information will be used to help us to get a better measure of what children eat. All information will remain confidential, the children will not be identified. As a thank-you we will give each child taking part a certificate of achievement and a University of Newcastle pen. The school will also be given a book token to the value of 50 pence for each child who takes part.

If you would like your child to take part please:

- Complete the enclosed consent form
- Return it to school as soon as possible

Thank you very much for taking the time to read this.
Yours sincerely

Dr Ashley Adamson
Lecturer

Emma Foster
Nutritionist - Project co-ordinator

If you would like more information please call us on 0191 2225276

Appendix 23 School 3 – Recruitment letter to parents for children to complete a School dinner diary (Approach 2)

Newcastle University Food Study

Dear Parent or Guardian.

We need your help!!

What we eat in the early years is important for health in adult life. Measuring food intake in young children is very difficult. Your child's school has been specially chosen to help us develop a method of measuring food intake in children. Would you and your child be interested in helping with the study? We will be carrying out the study in Welbeck Primary School in June of this year and would really like you to take part.

What would be involved?

- We would ask your child to record everything they eat and drink at school dinners for two days
- We would ask your child to attend two 10 minute interviews at school

How will the information be used?

This work will help us find out how children see and remember food portion sizes. The information will be used to help us to get a better measure of what children eat. All information will remain confidential, the children will not be identified. As a thank-you we will give each child taking part a certificate of achievement and a University of Newcastle pen. The school will also be given a book token to the value of 50 pence for each child who takes part.

If you would like your child to take part please:

- Complete the enclosed consent form
- Return it to school as soon as possible

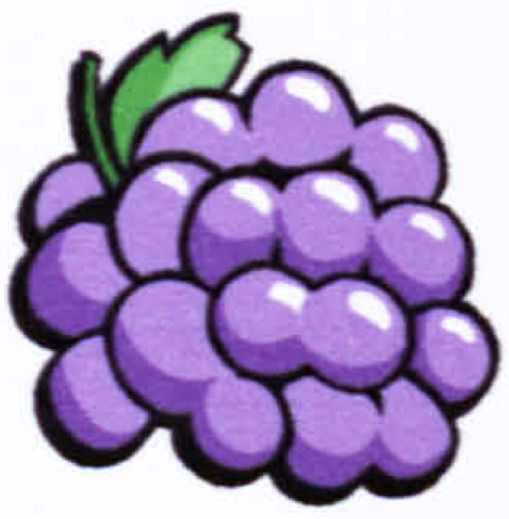
Thank you very much for taking the time to read this.
Yours sincerely

Dr Ashley Adamson
Lecturer

Emma Foster
Nutritionist - Project co-ordinator

If you would like more information please call us on 0191 2225276

Appendix 24 School 4 – Recruitment letter to parents for children to complete a food diary (Approach 1)



Newcastle University Food Study

Dear Parent or Guardian.

We need your help!!

Measuring food intake in young children is very difficult. However, what we eat in the early years is important for health in adult life. Your child's primary school has been specially chosen to help us develop a method of measuring food intake in children. Would you and your child be interested in helping with the study? We will be carrying out the study in St Charles' Primary School in July of this year and would really like you to take part.

What would be involved?

- For two days we would like you to keep a record of what your child eats and drinks.
- We would like you to weigh foods consumed or prepared at home and to help your child keep a diary of physical activity.
- We would ask your child to attend 2 short interviews at school where we would ask them to chose a photograph or a food model which looks most like the amount of food they ate.
- We would also like to weigh your child at school.

How will the information be used?

We will use the weights of recorded by the parents taking part in the study to compare with the weights of foods selected by children from a series of photographs or models of foods. The information collected will be used to develop methods to accurately measure what primary school children eat. All information will remain confidential as individual children will not be identified.
As a thank-you we will give each child taking part a certificate of achievement and a University of Newcastle pen. The school will also receive a book token to the value of 50 pence for each child who takes part.

If you would like your child to take part please:

- Complete the enclosed consent form
- Return it to school as soon as possible

Thank you very much for taking the time to read this.
Yours sincerely

Dr Ashley Adamson	Emma Foster
Lecturer	Nutritionist - Project co-ordinator

If you would like more information please call us on 0191 2225276

Appendix 25 Instructions for parents on completing food diaries (Approach 1) Chapter 5

Instructions for filling in the diary

Please record everything you eat and drink during the day.

Please give as much detail as possible about the foods you eat. For example how was it cooked or if you eat a sandwich did you have white or brown bread, margarine or butter.

Please give the weights of foods consumed wherever possible

You may draw the food or drink if you prefer.

If you have any questions about filling in the food diary or any other part of the project please contact me during the day on (0191) 2825102.

Thank you,

Emma Foster

Human Nutrition Research Centre
Univeristy of Newcastle

Dear Parent or Guardian,

Thank you for agreeing to your child taking part in this study. We would like your child to complete the enclosed food diaries covering **Wednesday** and **Thursday** of this week.

We would like you and/or your child to write down everything your child eats and drinks during the two days. The diary has spaces where your child can draw their food if they like, we hope that the drawings will help them to remember the foods that they have eaten at school, when they get home. For foods eaten or prepared at home (including packed lunch) we would like you to use the scales provided to weigh each food.

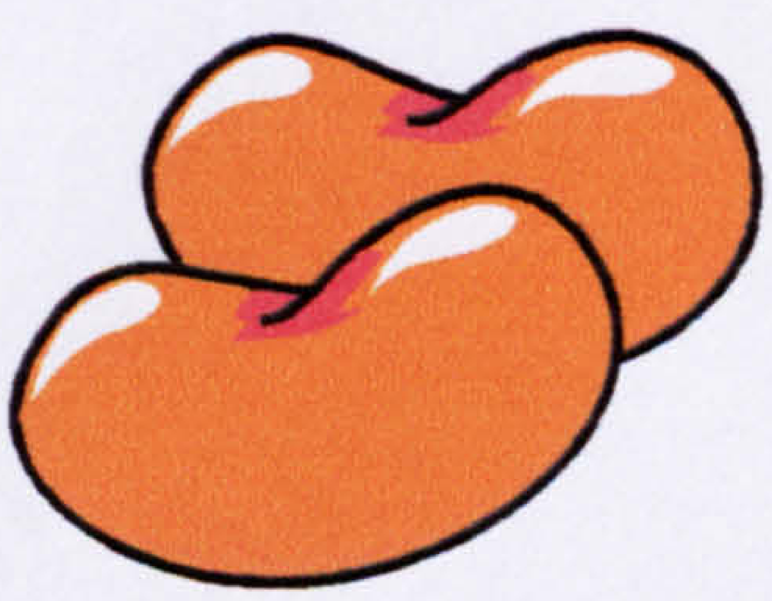
Your child will be interviewed at school the following day, by a nutritionist experienced in collecting dietary data from children. **It is essential, for the interviews, that the children bring the diaries into school with them on each of the days.**

At the back of the food diary is a physical activity diary. We would like your child to record any activities that they do on each of the two days.

As a thank you for taking part in this study your child will receive a certificate of achievement from the University of Newcastle and a University of Newcastle pen.

If you have any questions about filling in the food diary or any other part of the project please contact me during the day on (0191) 2825102.

Yours sincerely,



Emma Foster.
Project Nutritionist

Appendix 26 Instructions for parents with children completing School Dinner Diaries (Approach 2) Chapter 5

Dear Parent or Guardian,

Thank you for agreeing to your child taking part in this study. We would like your child to complete the enclosed food diary covering school dinners on Wednesday and Thursday of this week.

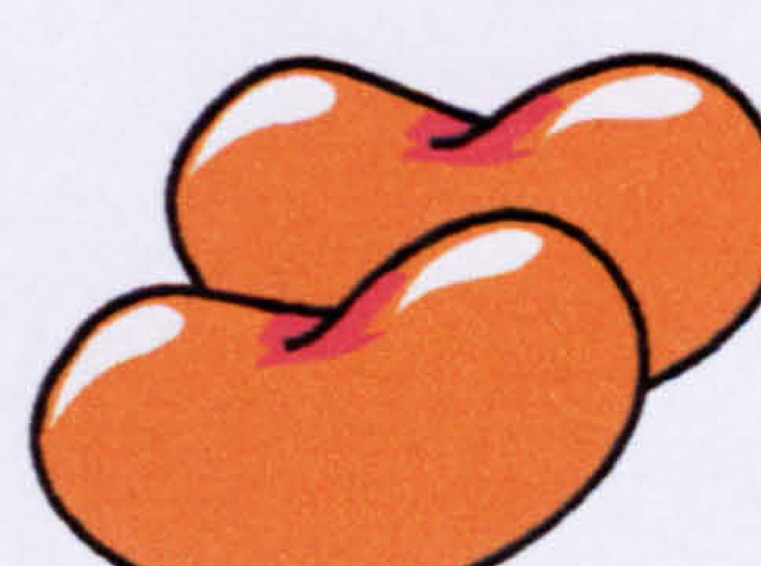
We would like you and/or your child to write down everything your child eats and drinks for school dinner. The diary has spaces where your child can draw their food if they like, we hope that the drawings will help them to remember the foods that they have eaten when they get home. Your child will be interviewed at school the following day, by a nutritionist experienced in collecting dietary data from children, to determine the amounts of foods eaten.

It is essential, for the interviews, that the children bring the diaries into school with them on each of the days.

As a thank you for taking part in this study your child will receive a certificate of achievement from the University of Newcastle and a University of Newcastle pen.

If you have any questions about filling in the food diary or any other part of the project please contact me during the day on (0191) 2825102.

Yours sincerely,



Emma Foster.
Project Nutritionist

Appendix 27 Example portion mix for food portion sizes included in the Portion Size Perception Interview (Approach 3) Chapter 5

Portion Mix 1

Food	Portion size
Chips	M
Cake	S
Baked beans	M
Sausage	L
Mashed potato	L
Bread	S
Apple	L
Ham	M
Macaroni	M
Rice Krispies (and milk)	L
Squash	S
Ice Cream	L
Banana	M
Tomato Ketchup	S
Cheese	S

Appendix 28 Differences in portion size estimation by food type

- **Apple – Single solid item varying in size and shape**

The children's estimates of portion size were on average 118% of the actual weight of the apple. There was no gender difference (p=0.74). The older children were on average more accurate than younger children but not significantly (p=0.49), 116% compared with 121% for the younger children. There was no significant difference between estimates based on photographs and estimates based on models (p=0.19). The estimates based on photographs were slightly more accurate on average, 116% compared with 120% for the models.

- **Bananas – Single solid item varying in size and shape**

The children's estimates were on average 105% of the actual weight of the banana. There was a gender effect which reached marginal significance (p<0.10), with the boys doing better than the girls. The boys were very accurate in their estimates (99.5%) whereas the girls overestimated (109%). The older and younger children had identical mean scores for accuracy (p=0.96). There was no significant difference in accuracy between children using models to estimate portion size compared with those using photographs (p=0.47), although the estimates were marginally more accurate on average when children used the photographs (104%) compared with models (106%).

- **Baked beans – Small homogenous pieces of solid in liquid**

Overall the children's estimates of portion size were on average 138% of the actual weight of the baked beans. There was no gender difference with boys and girls having almost identical scores for accuracy (p=0.94). The older children were significantly more accurate than the younger children (p=0.01), giving estimates of 122% compared with 165%. There was no significant difference between estimates based on photographs and estimates based on models (p=0.17). The estimates based on photographs appeared to be slightly more accurate on average, 130% compared with 147% for the models, but this difference did not reach significance.

- **Bread – Dry homogenous large pieces, slices**

The children's estimates of portion size were on average 68% of the actual weight of the bread that is the children grossly under-estimated the portion size of the bread. There was no gender difference with boys and girls having almost identical scores for accuracy ($p=0.89$). There was no significant difference in accuracy with age ($p=0.69$). The younger children were marginally less accurate, 66% compared with 70% for the older children. Children's estimates based on photographs were significantly more accurate, 77% of actual weight compared with 60% for the models ($p<0.001$).

- **Cake – Wedge of circular food with varying depth**

Overall the children's estimates of portion size were on average 131% of the actual weight of the cake. Boys were more accurate in their estimates than their female counterparts, 120% compared with 139%. This reached marginal significance ($p=0.08$). There was no significant difference in accuracy with age ($p=0.19$). The older children were marginally more accurate, 125% compared with 140% for the younger children. Children's estimates based on models were significantly more accurate ($p<0.01$), 102% compared with 159% for the photographs.

- **Cheese – Thin slices varying in size and shape**

Overall the children's estimates of portion size were on average 152% of the actual weight of the cheese. Girls were significantly more accurate than boys ($p=0.07$) 144% compared with 162%. The older children were slightly more accurate on average but not significantly ($p=0.63$), 150% compared with 155% for the younger children. There was no significant difference between estimates based on photographs and estimates based on models ($p=0.38$). The estimates based on models were slightly more accurate on average, 148% compared with 156% for the photographs.

- **Chips – Several medium size whole pieces, similar shapes but varying in size**

Overall the children's estimates of portion size were on average 211% of the actual weight of the chips. i.e. the children grossly over-estimated the portion size of chips. There was no gender difference with boys and girls having almost identical scores for accuracy (p=0.93). The older children were more accurate in their estimates, 200% compared with 229% for the younger children. This reached marginal significance (p<0.10). Children's estimates based on photographs were significantly more accurate than estimates using the food models, 185% compared with 237% (p<0.01).

- **Ham – Slices of varying thickness and shape**

Overall the children's estimates of portion size were on average 114% of the actual weight of the ham. Boys were slightly more accurate in their estimates, 107% compared with 120% for girls. This difference reached marginal significance (p<0.10) The older children were significantly more accurate in their estimates (p=0.02), 107% compared with 126% for the younger children. Children's estimates based on models were significantly more accurate than those based on photographs (p=<0.01), 94% compared with 134% for the photographs.

- **Ice cream – Stiff semi solid mass**

Overall the children's estimates of portion size were on average 97% of the actual weight of the ice cream. There was no gender difference (p=0.56) boys were slightly more accurate in their estimates, 99% compared with 96% for girls. The older children were more accurate in their estimates, 93% compared with 104% for the younger children. This reached marginal significance (p<0.10). There was a significant difference in children's estimates of portion size using the photographs and the models (p<0.01). Children over-estimated the portion size of ice cream using the photographs (131%) and under-estimated portion size using the models (65%).

- **Tomato ketchup – Amorphous, liquid food**

Overall the children's estimates of portion size were on average 106% of the actual weight of the tomato ketchup. There was no gender effect ($p=0.15$). Girls underestimated the weight (98%) whereas the boys overestimated (116%). There was a significant effect of age ($p<0.01$). Older children under-estimated the weight (92%) whereas the younger children over-estimated the weight (128%). The older children were closer to the actual weight of the ketchup. Children's estimates using models were slightly more accurate, 98% compared with 114% for the photographs there was weak evidence for a significant effect of portion size assessment aid ($p<0.1$).

- **Rice Krispies – Mound of homogenous small sized pieces**

Overall the children's estimates of portion size were on average 117% of the actual weight of the Rice Krispies. There was no significant gender effect ($p=0.19$), however girls were slightly more accurate than boys, 113% compared with 122%. The older children were significantly more accurate in their estimates, 109% compared with 130% for the younger children ($p<0.01$). Children's estimates based on models were significantly more accurate ($p<0.01$), 111% compared with 123% for the photographs.

- **Macaroni cheese – Amorphous, small homogenous pieces of solid in liquid**

Overall the children's estimates of portion size were on average 164% of the actual weight of the macaroni cheese. There was no gender difference ($p=0.58$) with boys being slightly less accurate, 169% compared with 161% for the girls. The older children were more accurate in their estimates, 154% compared with 181% for the younger children. This reached marginal significance ($p<0.10$). Children's estimates based on models were significantly more accurate ($p<0.01$), 141% compared with 188% for the photographs.

- **Milk (over cereal) – Liquid served over another food**

Overall the children's estimates of portion size were on average 199% of the actual weight of the milk i.e. the children estimated the portion of milk to be double the actual weight on average. There was no gender difference with boys and girls having almost identical scores for accuracy (p=0.95). The older children were more accurate in their estimates, 190% compared with 214% for the younger children. This reached marginal significance (p=0.06). Children's estimates based on photographs were significantly more accurate (p<0.01), 165% compared with 234% for the models.

- **Mashed potato – Stiff, semi-solid mass**

Overall the children's estimates of portion size were on average 144% of the actual weight of the mashed potato. There was no gender difference with boys and girls having similar scores for accuracy (p=0.57). The older children were significantly more accurate in their estimates (p=0.01), 130% compared with 167% for the younger children. Children's estimates based on models were significantly more accurate (p<0.01), 115% compared with 174% for the photographs.

- **Sausages – Single item varying in size and shape**

Overall the children's estimates of portion size were on average 198% of the actual weight of the sausages. i.e. the children grossly over-estimated the portion size of sausages. There was no significant gender effect (p=0.47), however boys over-estimated portion size to a greater extent than girls, 215% compared with 185%. There was no significant difference in accuracy of estimates with age (p=0.22). The older children were more accurate in their estimates, 178% compared with 230% for the younger children. Children's estimates based on models were significantly more accurate (p<0.01), 127% compared with 269% for the photographs.

- **Squash - Liquid**

Overall the children's estimates of portion size were on average 114% of the actual weight of the squash. There was no gender difference ($p=0.46$). There was a trend for boys to be slightly more accurate, 111% compared with 116% for the girls. There was no difference in accuracy with age. The older and younger children had almost identical mean scores for accuracy ($p=0.98$). Children's estimates based on models were significantly more accurate ($p<0.01$), 99% compared with 129% for the photographs.